Volume 25 JUNE, 1941 Number 6

BULLETIN
of the
American Association *of* Petroleum Geologists

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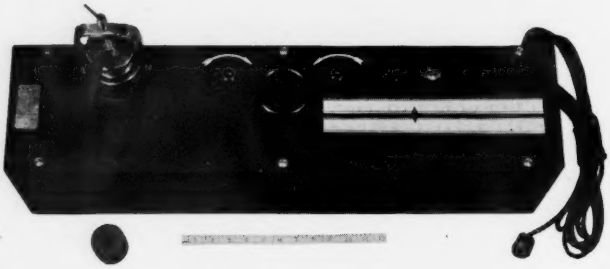
CORE ANALYSIS EQUIPMENT

The HAYWARD Permeameter



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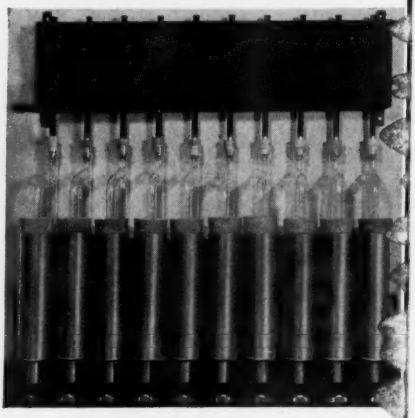

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of the

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OFFICE OF PUBLICATION, 708 WRIGHT BUILDING, TULSA, OKLAHOMA

THE BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS is published by the Association on the 15th of each month. Editorial and publication office, 708 Wright Building, Tulsa, Oklahoma. Post Office Box 979.

THE SUBSCRIPTION PRICE to non-members of the Association is $15.00 per year (separate numbers, $1.50) prepaid to addresses in the United States. For addresses outside the United States, an additional charge of $0.40 is made on each subscription to cover extra wrapping and handling.

British agent: Thomas Murby & Co., 1 Fleet Lane, Ludgate Circus, London, E. C. 4.

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BOX 979
TULSA, OKLAHOMA

Entered as second-class matter at the Post Office at Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

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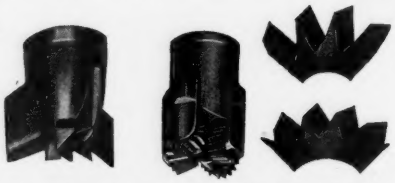

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Volume 25 Number 6

BULLETIN
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JUNE, 1941

WILDCAT DRILLING IN 1940[1]

FREDERIC H. LAHEE[2]
Dallas, Texas

ABSTRACT

The total number of wildcats drilled in 1940 was 3,038, and the footage drilled was 10,253,948, as contrasted with 2,589 holes and 8,624,602 feet, respectively, in 1939. The average depth of hole increased from 3,331 feet to 3,375 feet for all states, and from 4,145 feet to 4,284 feet in the southern states. More locations were based on technical advice than hitherto, and the percentage of successes increased from 10.4 to 12.0.

This paper reviews data on wildcat drilling for the sixth consecutive year.[3] The states from which information was available are indicated in Figure 1.

We have continued to use the definition of a wildcat as a hole drilled completely outside the known boundaries of pools already developed, and far enough from producing areas to be essentially a test of new possibilities. Generally speaking, such a hole would be at least 2 or 3 miles from production; but, where subsurface conditions may change within short distances, as in the case of lensing sands and salt-dome structures, and where, consequently, predictions based on the known may turn out to be greatly in error, a test hole may be regarded as a wildcat even if it is only $\frac{1}{2}$ or $\frac{3}{4}$ mile from production or from an abandoned dry hole.

In compiling the data, questions have arisen as to just how to classify footage drilled in certain wells which are strictly neither dry holes nor producers from top to bottom. For instance, within the

[1] The writer acknowledges with thanks the kind assistance and coöperation of the following gentlemen in compiling data for this summary: A. P. Allison, L. J. Bateman, A. H. Bell, K. E. Born, N. Burnett, G. E. Burton, D. H. Cardwell, C. H. Coldwell, R. J. Cullen, G. F. Fix, M. H. Funk, G. C. Gester, E. A. Koester, C. S. Lavington, G. D. Lindberg, A. M. Lloyd, R. W. Mallory, D. J. Munroe, G. W. Myers, Jack Parker, C. H. Row, G. C. Sleight, L. C. Smith, S. D. Sumerford, and E. B. Wilson.

Manuscript received, March 22, 1941. Read by title at the Association meeting in Houston, April 3, 1941.

[2] Chief geologist, Sun Oil Company.

[3] See this *Bulletin*, Vol. 21, pp. 1079–82; Vol. 22, pp. 645–48, 1231–35, 1236; Vol. 23, pp. 789–94; and Vol. 24, pp. 953–58.

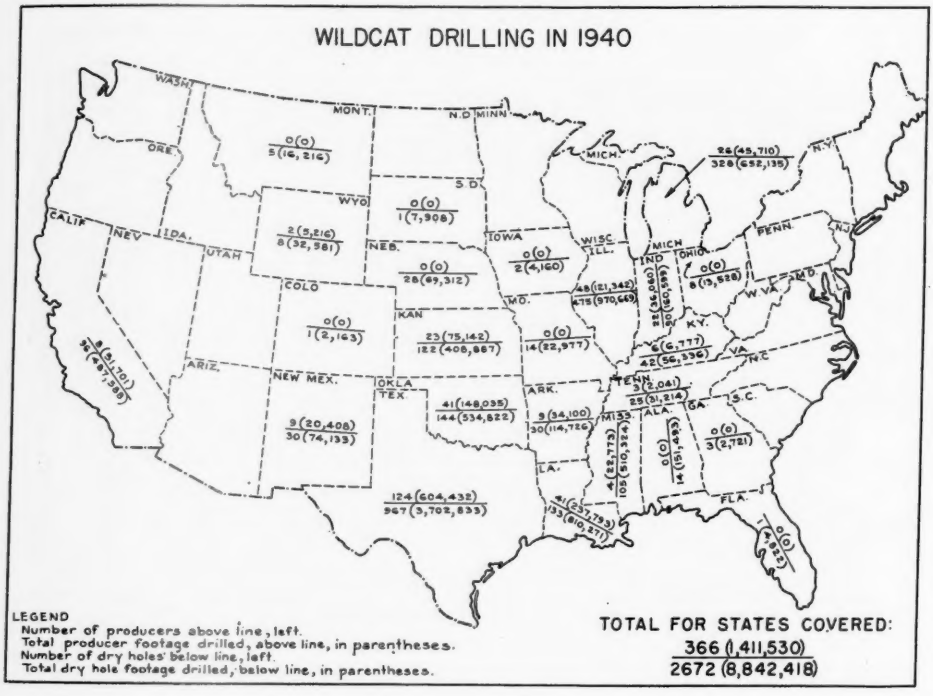
WILDCAT DRILLING IN 1940
WASH.
ORE.
CALIF.
NEV.
IDA.
MONT.
N.D.
MINN.
S.D.
WYO.
UTAH
COLO.
NEB.
IOWA
WISC.
ILL.
MICH.
IND.
OHIO
PENN.
N.Y.
N.J.
W.VA.
MD.
KY.
VA.
N.C.
S.C.
GA.
FLA.
ALA.
MISS.
TENN.
ARK.
LA.
KAN.
MO.
OKLA.
TEX.
ARIZ.
NEW MEX.
0(0) 5(16,216)
0(0) 1(7,908)
2(5,216) 8(32,981)
0(0) 28(89,312)
0(0) 2(4,160)
48(121,342) 475(970,649)
28(45,710) 328(652,135)
0(0) 8(19,828)
6(6,777) 42(56,336)
0(0) 1(2,163)
23(75,142) 122(408,887)
0(0) 14(22,977)
3(2,041) 25(31,214)
41(148,035) 144(534,822)
9(34,100) 30(114,726)
0(0) 3(2,721)
9(20,408) 30(74,133)
124(604,432) 967(3,702,833)
0(0) 1(4,822)
LEGEND
Number of producers above line, left.
Total producer footage drilled, above line, in parentheses.
Number of dry holes below line, left.
Total dry hole footage drilled, below line, in parentheses.
TOTAL FOR STATES COVERED:
366 (1,411,530)
2672 (8,842,418)

FIG. 1


NEW MEXICO
OKLAHOMA
ARKANSAS
MISSISSIPPI
ALABAMA
GEORGIA
SOUTH CAROLINA
FLORIDA
LOUISIANA
TEXAS
0 (0) 7 (32,997)
9 (20,408) 26 (63,161)
35 (123,060) 251 (699,740)
5 (26,346) 67 (258,985)
9 (34,100) 30 (114,726)
22 (61,674) 64 (275,167)
24 (22,773) 105 (510,324)
0 (0) 14 (151,493)
0 (0) 3 (2,721)
0 (0) 1 (4,822)
17 (60,791) 62 (253,204)
15 (114,389) 109 (804,151)
19 (176,119) 68 (535,104)
3 (6,216) 117 (220,983)
49 (273,630) 354 (1,432,773)
WILDCATS, 1940
TOTAL
187 (919,506)
1279 (5,360,351)
ONE PRODUCER FOOT
FOR EVERY
5.83 FEET DRY

FIG. 2

boundaries of a pool a hole may be drilled below the lowest pay zone in search of some unknown new "pay." In the sense that it is exploring for deeper untested possibilities, its footage drilled below the lowest known "pay" is wildcat. It might be called a semi-wildcat. If it discovered oil or gas in a deeper formation this extra footage might be listed as semi-wildcat discovery footage; and if, on the other hand, it failed to find a deeper "pay," the depth drilled below the lowest producing formation would then be termed semi-wildcat dry footage. For the most part this kind of semi-wildcat footage has been omitted from our statistics. It comprises only a small percentage of the whole.

A somewhat similar case is that of a wildcat well drilled through one or more prospective pay zones to a considerably greater depth and then plugged back to completion as a producer. However, in a hole of this kind, since the total depth would be charged against the cost of the completed producer, we have listed this total depth in the column for producers. Our statistics for 1940 do not always designate plugged-back footage, but in the nine states where this information was submitted (including California, Oklahoma, and Texas), the total bottom-hole footage plugged off was shown to be 208,761 feet in 153 discovery wildcats—not an inconsiderable percentage of the total producer figures.[4]

On the maps (Figs. 1 and 2), numbers in parentheses indicate total footage drilled; figures preceding parentheses indicate the number of holes drilled; figures above the cross line are for producing wells, both oil and gas; and figures below the cross line are for dry holes.

In the states covered in this review, as shown in Figure 1, and listed in Table I, during 1940 a total of 10,253,948 feet was drilled in 3,038 holes, divided as follows.

366 producers.....	1,411,530 feet
2,672 dry holes.....	8,842,418 feet

This means that 12.05 per cent of the holes drilled, and 13.77 per cent of the footage drilled, was successful in 1940. The average depth of hole was 3,375 feet.

In the southern states district (Fig. 2), in 1940, a total of 6,279,857 feet was drilled in 1,466 holes, divided as follows.

187 producers.....	919,506 feet
1,279 dry holes.....	5,360,351 feet

In this area, then, 12.76 per cent of the holes drilled, and 14.64 per cent of the footage drilled, was successful. The average depth of hole

[4] The reader is reminded that these figures of 153 wells and 208,761 feet are included in the figures of 366 producers and 1,411,530 producer feet, respectively, in Table I.

TABLE I

NUMBER OF OIL WELLS, GAS WELLS, AND DRY HOLES, DRILLED AS WILDCATS IN 1940

States	Oil Discovery		Gas Discovery*		Dry		Total Number of Holes	Total Footage Drilled	Average Depth of Hole in Feet†
	Number of Holes	Footage Drilled	Number of Holes	Footage Drilled	Number of Holes	Footage Drilled			
Alabama					14	151,493	14	151,493	
Arkansas	7	16,880	2	17,220	30	114,726	39	148,826	3,816
California	6	28,587	2	23,114	96	487,588	104	539,289	5,185
Colorado					1	2,163	1	2,163	
Florida					1	4,822	1	4,822	
Georgia					3	2,721	3	2,721	
Illinois	48	121,342			475	970,669	523	1,092,011	2,088
Indiana	17	28,600	5	7,460	90	160,599	112	196,659	1,756
Iowa					2	4,160	2	4,160	
Kansas	22	71,717	1	3,425	122	408,887	145	484,029	3,338
Kentucky, West	6	6,777			42	56,336	48	63,113	1,315
Louisiana	27	132,930	14	104,863	133	810,271	174	1,048,064	6,023
Michigan	22	40,735	4	4,975	328	652,135	354	697,845	1,971
Mississippi	4	22,773			105	510,324	109	533,097	4,891
Missouri					14	22,977	14	22,977	
Montana					5	16,216	5	16,216	
Nebraska					28	69,312	28	69,312	2,475
NW. New Mexico					4	10,972	4	10,972	
SE. New Mexico	6	14,270	3	6,138	26	63,161	35	83,569	2,387
Ohio, NW					8	13,528	8	13,528	
Oklahoma	35	133,291	6	14,744	144	534,822	185	682,857	3,702
So. Dakota					1	7,908	1	7,908	
Tennessee	3	2,041			25	31,214	28	33,255	1,187
Texas	98	461,567	26	142,865	967	3,702,833	1,091	4,307,265	3,948
Wyoming	1	1,676	1	3,540	8	32,581	10	37,797	
Totals	302	1,083,186	64	328,344	2,672	8,842,418	3,038	10,253,948	

* Gas and distillate wells are included under gas wells.
† Averages have been recorded here only for states where more than 25 holes were drilled in 1940.

TABLE II

COMPARATIVE STATISTICS FOR ALL STATES SHOWN IN FIGURE 2

	Producers Drilled				*Dry Holes Drilled*				*Total Number Wildcats Drilled*	*Average Depth of Hole (Feet)*	*Number of Dry-Hole Feet Drilled for Each Producer Foot*
	Holes		*Footage*		*Holes*		*Footage*				
	Number	*Per Cent*	*Feet*	*Per Cent*	*Number*	*Per Cent*	*Feet*	*Per Cent*			
1938	200	13.6	984,262	17.4	1,271	86.4	4,667,402	82.6	1,471	3,842	4.74
1939	161	12.6	779,345	14.8	1,113	87.4	4,501,669	85.2	1,274	4,145	5.90
1940	187	12.8	919,506	14.6	1,279	87.2	5,360,351	85.4	1,466	4,284	5.83

TABLE III

BASIS FOR LOCATING WILDCATS DRILLED IN 1940

State	*Geology*		*Geophysics*		*Geology and Geophysics*		*Sundry Non-Technical*		*Unknown*		*Totals*	
	Prod.	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*
Alabama		1		1		2		10				14
Arkansas	5	8	4	9						13	9	30
California	5	45	2	10	1	13		27		1	8	96
Colorado										1		1
Florida		1										1
Georgia								3				3
Illinois	12	140	32	107	1	11	2	168	1	49	48	475
Indiana	10	47	1	4	6	7		12	5	20	22	90
Iowa				1				1				2
Kansas	12	41	3	12	1	5	7	64			23	122
West Kentucky	6	33						9			6	42
Louisiana	23	66	18	61		1		4		1	41	133
Michigan	15	159		1			9	156	2	12	26	328
Mississippi	3	16	1	43		1		45			4	105
Missouri		3						3		8		14
Montana		4								1		5
Nebraska		8		1				19				28
New Mexico	6	20		1			3	7		2	9	30
Ohio, NW				2				3		3		8
Oklahoma	23	56	12	30			5	54	1	4	41	144
So. Dakota		1										1
Tennessee	3	4				2		17		2	3	25
Texas	73	549	27	162	13	37	9	194	2	25	124	967
Wyoming	2	2		1		2		1		2	2	8
Totals	198	1,204	100	446	22	81	35	797	11	144	366	2,672

was 4,284 feet. For comparison with statistics for this same area in 1938 and 1939, see Table II.

Selection of the location for a wildcat well may be based on geology (surface geology, subsurface geology, trend along known structural or stratigraphic conditions, local or regional, or shallow exploratory drilling); or it may be based on geophysics (exploration by seismograph, torsion balance, gravity meter, magnetometer, *et cetera*); or it may be based on some non-technical suggestion or requirement, such as "creekology," "hunch," "doodlebug," promotion, lease obligation, reported showing of oil or gas in holes previously drilled, *et cetera*. In many cases the reason for choosing the location can not be ascertained.

In Table III are listed the reasons for drilling the wildcats in 1940 using the best information available from men familiar with such statistics, each in his own state or district. According to these figures, 320 wildcats drilled on technical advice (geology and (or) geophysics) were successful (oil or gas), and 1,731 were dry; 35 holes located for non-technical reasons were producers, and 797 were dry; 11 producers and 144 dry holes were located for reasons unknown. These figures show that 15.6 per cent of the holes drilled on technical advice were producers as contrasted with 4.2 per cent successful in the case of the holes located without technical advice. Therefore, in 1940 locations based on technical recommendations were 3.7 times as successful as those drilled without such advice. In the southern states (Fig. 2), 4.4 per cent of the wildcats, located without technical advice, were producers, whereas 15.0 per cent of the holes located on technical advice were producers.

Comparing last year's figures[5] with figures for 1940, we note the following conspicuous changes.

1. The number of dry holes drilled in Kansas increased from 74 to 122; the dry hole footage, from 258,031 feet to 408,887 feet; whereas the number of discovery wells remained almost unchanged.

2. In Louisiana there was a gain in discovery wells, from 15 to 41, whereas the number of dry holes increased only a small percentage, from 125 to 133.

3. There was a tremendous increase in drilling in Mississippi, but almost entirely in dry holes, which increased from 16, with a total of 67,195 feet in 1939, to 105, with a total of 510,324 feet in 1940.

4. Oklahoma wildcat drilling showed a considerable increase, with 41 producers (148,035 feet), and 144 dry holes (534,822 feet), in 1940,

[5] F. H. Lahee, "Wildcat Drilling in 1939," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 6 (June, 1940), pp. 953–58.

as contrasted with 21 producers (82,272 feet) and 91 dry holes (388,470 feet) in 1939.

5. Texas had a small percentage gain in dry holes (from 906 to 967), and a small percentage loss in discovery wells (from 131 to 124), with a net gain in wildcats from 1,037 in 1939, to 1,091 in 1940.

6. The number of successful holes (discovery wells) out of the total number of wildcats drilled on technical advice rose from 13 per cent in 1939 to 15.6 per cent in 1940; and, on the contrary, successful holes drilled without technical advice decreased from 6 per cent of the total number of wildcats drilled in 1939 to 4.2 per cent of the total number in 1940, thus indicating a decided advantage on the side of technical advice.

7. Last year[6] we called attention to the fact that, whereas in 1937 there were 3 times as many discovery wildcats drilled on technical advice as there were drilled for non-technical reasons, in 1938 this factor had decreased to between 2.2 and 3.2, and in 1939 it had further decreased to between 1.5 and 2.2. Reasons were suggested for this condition. This year, in 1940, we find that this factor has jumped to 3.7. There has been a stronger tendency than hitherto to seek technical advice before selecting a wildcat location, and especially is this true where deep drilling is contemplated.

Our readers may be interested to have a few details, not appearing in the accompanying tables, with reference to the distribution of certain types of technical recommendations applied in locating wildcats during 1940. On subsurface geology 793 locations were made as compared with 155 made on surface geology. On seismographic work, mostly reflection shooting, 431 locations were made whereas the remaining 115 locations listed under geophysics in Table III were based on the other types of geophysical exploration. Subsurface geology is by far the most important guide for selection of wildcat locations.

[6] *Op. cit.*, p. 958.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1004-1015, 1 FIG.

REVIEW OF DEVELOPMENTS IN 1940, GULF COAST OF UPPER TEXAS AND LOUISIANA[1]

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ABSTRACT

The poor discovery record of the upper Texas Coast for 1940 is no improvement over that established for 1939. Coastal Louisiana, however, showed an advance in both the number and quality of new areas uncovered. The most noteworthy improvement of the year in Louisiana has been the increasing importance of the new reserves added to old fields through extensions and new sand discoveries.

During the past few years, a shift in the center of successful activity has given coastal Louisiana the lead over upper Texas. This shift coincided with the opening of the large area of only partially explored delta territory of Louisiana to intensive exploitation.

The increase in the number of economically marginal areas that are now being developed is credited to improvements in the technique of well testing and completion, mainly the introduction of the electric log, gun perforating and cement squeezing.

INTRODUCTION

There has been a slight increase in the discovery rate in the Gulf Coast district during the year 1940. The number of new areas in upper Texas has been increased from 10 for 1939 to 12 for 1940, and, in Louisiana, from 13 to 16 for the same periods. At the close of 1939, the Texas discoveries for that year were given a rating that was generally poor and this advance estimate has been fully substantiated by the continued poor showing of these new areas after a year of additional exploitation. The 12 Texas discoveries of the past year seem to have no greater claim to merit than had those of 1939 and it is now anticipated that a year hence, most of the discoveries of 1940 will still stand as units that are of no real importance from an oil-reserve standpoint. In Louisiana, where the outlook during several recent years has not been regarded as too promising, the situation has been partially reversed. The discoveries of 1939 have shown, in many cases, a much greater improvement than was anticipated and, in addition, some of the new fields of 1937 and 1938 have continued to multiply their reserves as a result of extensions and the discovery of new sands.

During the past few years, a shift in the location of successful activity has definitely given coastal Louisiana the lead over the upper Texas coast. This trend has become most pronounced during 1939 and 1940, for in these two years, Texas has fallen far behind its average

[1] Read before the Association at Houston, April 2, 1941. Manuscript received, March 5, 1941.

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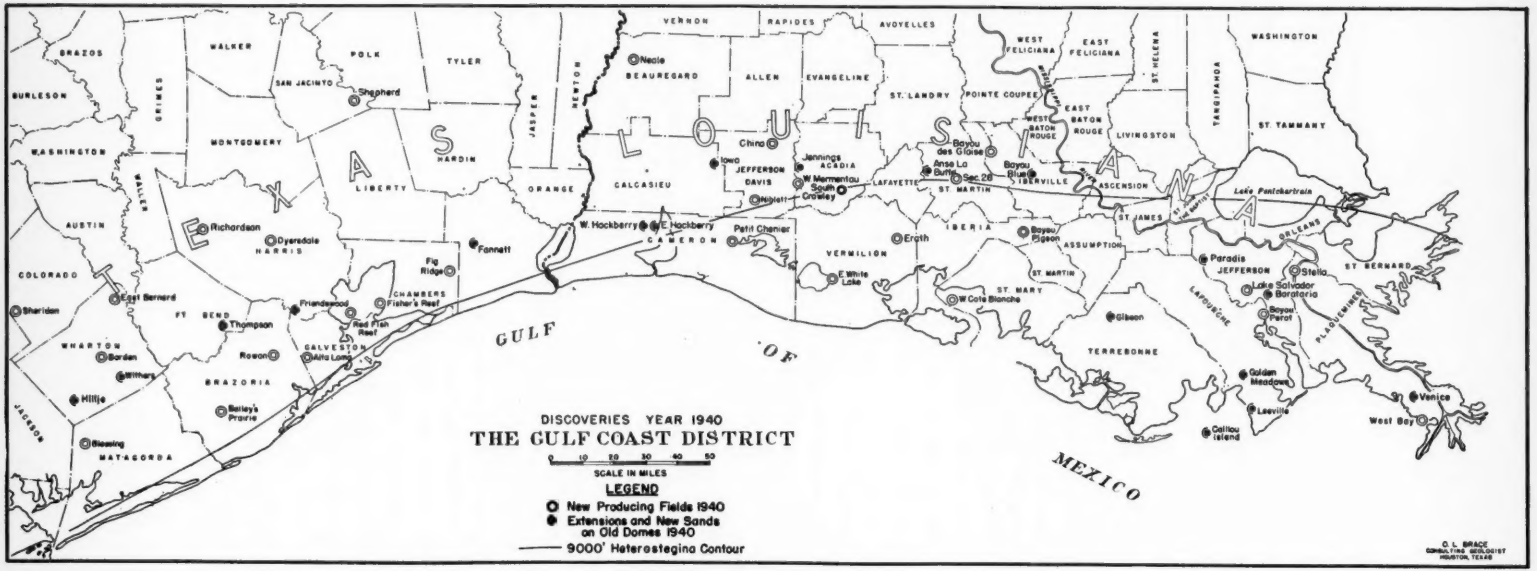

FIG. 1.—Map of Gulf Coast district showing new producing fields, extensions, and new sands on old domes, discovered during 1940. Previously discovered fields and domes are omitted in order to preserve legibility of map.

annual discovery rate of the past 10-year period. Numerous factors have contributed to this shift in leadership and some of them will be discussed briefly in the following paragraphs.

The present Gulf coastline follows a sweeping curve from the Mexican border north and east beyond the Louisiana line to the central part of Cameron Parish. Throughout this distance, there is a marked parallelism between the present shoreline and the shoreline that controlled the deposition of the younger coastal sediments. Eastward from the central Cameron Parish coast, the border of the Gulf swings southeast and maintains this direction to the mouth of the Mississippi River, at which point it turns sharply northward.

The sedimentary strike line does not follow the coast from Cameron Parish eastward, but progresses inland to cross the Mississippi River at a point a short distance south of the city of Baton Rouge and upstream from the mouth of the river a distance of 130 miles, as illustrated by the 9,000-foot *Heterostegina* contour placed on the accompanying map. This change in coastline direction in south Louisiana is the direct result of the tremendous delta-building activities of the Mississippi River and its distributaries, where deposition has been so rapid that shore currents have been unable to maintain the old shoreline. The result has been to erect a swampy land surface almost the entire width of the state that extends southward into the Gulf for many miles.

The stratigraphic zone that borders the Gulf along the upper Texas coast, and extends northeastward across Louisiana from western Cameron and Calcasieu parishes to the Mississippi River, shows a somewhat uniform distribution of salt plugs. From this standpoint, this trend may be regarded as of more or less equal potentiality in the two states. The discovery rate on each side has, in fact, been about equal, although Texas has furnished pools of much greater individual merit than has Louisiana.

Southward from this strip on the Louisiana side, the zone of swampy deltaic deposits represents a province that has no land equivalent on the Texas side. It is in this swampy area that most of the prolific Miocene discoveries of the past few years have been located and it is because of the geologically recent land surface created by the Mississippi River, that this rich territory has been made available for geophysical exploration and subsequent development.

Until a few years ago, most coastal activity was confined to the zone adjacent to the Gulf in Texas and to the equivalent Louisiana area that borders the deltaic swamp land on the north. During that period, Texas maintained the lead in both exploration and in the rate

of oil-field discovery and it was only with the exhaustion of first-class prospects in this intensively explored strip of territory that the rapid decline in rate and quality of discovery set in. Meanwhile, the entire Mississippi Delta area, which had previously been only partially investigated with refractions, was opened to exploration because of an improvement in geophysical transportation methods and technique. Thus Louisiana was enabled to start the development of a vast area of almost virgin, highly potential land at a time when upper coastal Texas was already on the decline.

Available facts seem to support the conclusion that an important part of the oil territory of the upper Texas coast may lie offshore under the waters of the Gulf. There is no present evidence to suggest that the zone of salt-dome occurrence narrows west of the Mississippi Delta and it may be tentatively assumed that the Gulf of Mexico is a potential source of salt-dome oil for a distance of at least 50 miles off the mouth of Galveston Bay. Whether or not it will ever be economically feasible to explore these waters for the domes that must exist is a question for the future to answer.

One of the conspicuous characteristics of the coastal discovery record in recent years has been the sharp increase in the number of new areas of a type that might be classed as economically marginal. By this is meant the area where exceptionally thin zones of saturation and high oil-gas ratios make it problematical that profits from production will ever return the cost of development. This type of oil occurrence has dominated the upper Texas coast discovery picture for several years and is a striking, although less important element in Louisiana. Credit for this increase in the number of new pools of this type may be given to the new technique of oil-well testing and completion, particularly to the introduction of the electric log, the gun perforator, and to the recently perfected method of cement squeezing. Sands which in less technical days would have been passed up as of no consequence, are to-day considered worth a string of pipe if only they register on the electric log and show some saturation in a side-wall core. While it is true that these new tools have added to the science of oil production, it is probable that with our present economic set-up the industry in general would profit greatly if the majority of these marginal deposits could remain undiscovered until some future period.

TEXAS DISCOVERIES

The majority of the 12 new productive areas that were found on the upper Texas coast during 1940, are located in the deep coastal zone of normal Frio production. At the time this paper is written,

none of these new areas appears to justify a first-class rating, although it is true that lack of development makes it hazardous to offer any advance appraisal of potentialities. Four of the discoveries are rated, on initial performance, as gas and distillate areas. One of these, *Blessing*, Matagorda County discovery of The Texas Company, shows enough promise that plans are being considered for a recycling plant. Gas is found here in Frio sand at 8,290 feet, with two wells already completed. A second gas area is *Baileys Prairie*, Brazoria County, where Glenn McCarthy made a producing well in the Frio at 11,860 feet, a record for the Texas Coast. At *Borden*, Wharton County, T. F. Hutchins developed a small gas well in new territory from Frio sand encountered at 4,770 feet. No further efforts have been made to develop this strike. Of considerable interest but of questionable oil value is a fourth gas discovery, Harrison and Abercrombie's Wilcox sand completion on the *Shepherd* prospect in San Jacinto County. Numerous dry holes had previously been drilled in this area to test both Yegua and Wilcox sections, before completion of the present producer at a depth of 8,215 feet.

The first oil discovery of the year was made on an old torsion-balance prospect at *East Bernard*, Wharton County, where H. C. Cockburn found a small production of high-gravity oil in a sand at 8,074 feet that is tentatively correlated with the Cook Mountain. No additional development has followed the initial completion.

The discovery at *Alta Loma*, Galveston County, appears to have considerable potentiality. The Stanolind Oil and Gas Company's Hulen No. 1 blew in, out of control, during May, 1940, from Frio sand at 9,166 feet. The flow of 34° gravity oil was estimated at 400 barrels hourly during the uncontrolled period and the total output was something in excess of a quarter million barrels. Only one additional well has been completed so that there is little information yet on which to base an opinion as to the real merits of the area. The prospect was first found by Humble in 1937 with the reflection seismograph.

The completion at *Sheridan*, Colorado County, is the second Wilcox oil discovery of the year, the first being the Neale area, Beauregard Parish. The initial well, Plow No. 1, was completed by the Shell Oil Corporation on May 25, 1940, in 30 feet of saturated Wilcox sand at 8,200 feet. The oil is of 41° gravity. Strike faulting is the predominant factor in accumulation, there being virtually no evidence of uplift in the Yegua section. Three commercial producers were completed by the end of the year.

A discovery was made by the Sun Oil Company at *Fig Ridge*,

Chambers County, during June. This area adjoins Seabreeze on the north and is thought to be a part of the same faulted and folded unit. The first well, Smith No. 1, found 32° gravity oil in a 15–20-foot Frio sand member at 8,849 feet. No additional wells have been drilled.

Rowan, a new gas and distillate discovery in Brazoria County, was completed during June. The discovery well, Rowan and Nichols' Hubbard No. 1, encountered production in Frio sand at 8,960 feet. The importance of the strike from an oil-reserve standpoint is still uncertain although several oil wells have been finished in a sand at 8,500 feet, in addition to several gas wells in the lower sand. Present indications are that the productive area will be small.

Richardson (Ogburn), Harris County. This prospect, proved for commercial oil and gas during June, 1940, has been under development for a period of 6 years. Eight dry holes had previously been drilled and the location for the discovery test was guided by subsurface structural control. Christian and Carpenter's Marks No. 1, the first well showing oil or gas in quantity, was completed in the 6,900-foot Yegua sand for gas and distillate. Subsequently, four gas wells and two oil wells were finished, proving the presence of at least four sands with commercial possibilities of some character.

Dyersdale, Harris County, is a new field located a short distance north of the city of Houston. Production of 24° gravity premium crude is obtained from the top of the Frio sand section at 4,050 feet, in an updip area where accumulation is not normally to be anticipated in sands younger than Yegua.

Discovery was made by H. C. Cockburn in the Burkett No. 1 during September. At the close of the year, eight producing wells had been completed but it still is not possible to interpret the structure in detail. It is probable, however, that accumulation occurs in a minor trap, controlled by strike faulting that is down-thrown coastward, similar in type to the occurrence at Fairbanks. Present indications are that the productive area will be small.

Geophysical work on coastal waters resulted in the discovery of two more areas in Galveston Bay. *Red Fish Reef*, located 8 miles east of Kemah, in the center of the Bay, was discovered in August and *Fishers Reef*, on the east side of the Bay, off the Chambers County shore, was found in December. Both discoveries were made by the Humble Oil and Refining Company, in Frio sand at an approximate depth of 8,800 feet. The initial well at Red Fish Reef was a gas and distillate producer but an additional gas well and one oil well have since been completed. The production in the more recent strike at Fishers Reef is of 32° gravity oil, with low oil-gas ratios.

EXTENSIONS TO PROVED AREAS

Developments about the margins of productive areas have resulted in improving the reserve status of several fields. At *Hillje*, Wharton County, a one-well field at the beginning of the year, 10 producers have been completed. *Friendswood*, Harris County, and *Fannett*, Jefferson County, were given further important extensions. *Thompsons*, Fort Bend County, experienced further flank extension toward the north and south.

The most important extension of the year was made in connection with the *Withers* field, Wharton County. At this locality, The Texas Company isolated a 500-foot fault to the north of established production and they have opened a new oil area on the upthrown side that is probably of greater importance than the original pool.

At the same time, it should be pointed out that the majority of the discoveries of 1939 have failed to materialize into fields of real commercial consequence. *Rosenberg*, Fort Bend County, and *Aldine*, Harris County, have shown no improvement since discovery. *Buttermilk Slough* and *Collegeport*, Matagorda County, are still to be classed as unimportant gas-distillate areas. *Anchor*, Brazoria County, regarded as rather promising in the early stages of exploration, has developed no worthwhile oil, although a considerable quantity of distillate is being recovered as a by-product of gas production. *Chocolate Bayou*, also in Brazoria County, is in the same category, but more extensive drilling might result in promising disclosures. *Caplen*, *South China*, and *Martha* have been definitely established as oil pools but none of these deserves more than a secondary rating at this time.

LOUISIANA DISCOVERIES

Of the 16 productive areas found in coastal Louisiana for 1940, all but four are located in the lower marshy delta area of Miocene sand production. The remaining four discoveries include three Oligocene producers of rather questionable value, all located in Jefferson Davis Parish, and one Wilcox field. A brief description of these new areas follows in the order of their discovery.

Bayou Perot, Lafourche Parish, was the first discovery of the year 1940 for coastal Louisiana. The discovery well, the Tide Water Oil Company's Delta Farms No. 1, first showed for a producer during early March from Miocene sand at 11,290 feet after previous abandonment of one deep dry hole. Isolation of favorable structure at this location resulted from reflection work, followed by gravimeter. Before the end of the year, the discovery well went to water and the block was returned by the Tide Water to the Delta Farms Company. In the

meantime, The Texas Company, owners of leases on the flank of the structure, completed one good commercial well and now have a second well ready for completion.

Bayou Pigeon, a Plymouth Oil Company discovery, is located in Iberia Parish. The discovery well, McHugh Heirs No. 1, was completed for a small well in March in a sand of Miocene age at 8,052 feet, after plugging back from 10,000 feet. Several other favorable sands were drill-stem tested up the hole. Two additional wells have been completed at the same depth and one more is drilling. Acreage on which the discovery is located, was farmed out by the Shell Oil Corporation who originally worked the area with the reflection seismograph.

West Côte Blanche, St. Mary Parish.—This area was worked by The Texas Company in 1939 with reflection seismograph and the first test, State of Louisiana No. 1, resulted in a producer. Production was obtained on March 22 in Miocene sand at 3,109 feet, after plugging back from 8,685 feet. Salt has since been found at 7,820 feet in the State No. 6. There are now several producers in the field and it seems that there will be numerous formations that will contain oil above the salt (super-cap) and possibly on the flanks. Present producing depths at 3,109, 4,948, and 7,620 feet are all above the salt.

Neale, Beauregard Parish, is the one Louisiana Wilcox (Eocene) discovery of the year. It is located on the inner margin of the Coastal Plain near the Texas border. The structure, a low relief fault trap, was found by means of reflection seismograph. The discovery well, Witmer No. 1, was completed, March 28, 1940, in the top Wilcox sand at 8,362 feet.

Eight producing wells have been completed in the field and the proved area appears to be relatively large. Indications are, however, that per-acre recoveries are to be low due to the thin section of saturated sand and the low permeabilities that seem to characterize most downdip Wilcox productive areas.

Niblett is a reflection-seismic prospect located in Jefferson Davis Parish. The Continental Oil Company drilled a test during March that was completed as a small producer in *Marginulina*-Frio sand at 11,604 feet. The well went to water after producing 5,100 barrels of oil and reworking failed to effect a shut-off. The well was abandoned and the lease block has now been dropped by the Continental.

Erath, Vermilion Parish, was discovered by The Texas Company in April, 1940. The structure, a large dome, with many major faults, was outlined as early as 1936, by the reflection seismograph. The discovery well, School Board No. 1, was completed in a thin streak of

Miocene sand at 11,378 feet but it has not been a consistent producer. Since discovery, two deep dry holes have been abandoned and additional wells are being drilled. In October, the Humble temporarily reestablished the area by completion of a distillate well at 10,173 feet. This is probably the outstanding coastal disappointment of the year.

Bayou des Glaise, Iberville Parish.—This prospect was outlined by the Calcasieu Oil Company in 1926 with the refraction seismograph. During the years 1928–32, five dry holes were drilled in the area. This early development located the salt at 3,697 feet and otherwise confirmed the presence of the uplift. Commercial discovery was made by the Humble Oil and Refining Company on April 24, 1940, in the Wilberts No. 2-B in Miocene sand at 8,648 feet. This well, however, was abandoned a few months later. The record of the dome is one oil well and seven dry holes, with no production at the end of the year.

East White Lake.—This prospect, located in Vermilion Parish, was classed as a discovery during July when the Union Oil Company of California found a productive sand in the Miocene at a depth of 11,098 feet. Prior to the drilling of this test, the area had been shot by both refractions and reflections and three deep dry holes had been drilled. Geophysical study indicates that the East White Lake dome has about 600 feet of closure, is highly faulted, and covers approximately 10 sections.

At the end of the year, there was one producing well in the area, and two wells drilling.

Petit Chenier, a prospect in Cameron Parish, was partially proved for commerical production by the Phillips Petroleum Company's Miami Corporation No. 1, completed on July 18, 1940. This test found gas and distillate in several sands down to 10,655 feet but was finally completed in a gas sand at 10,194 feet. It is located between two Humble dry holes, both of which were drilled below 10,000 feet.

West Mermentau, Jefferson Davis Parish.—The discovery well, H. M. Naylor's Acadia Development Company No. 1, was drilled on surface and subsurface geology. Little is known about structural details but it is possible that the discovery well occupies a fault trap located on the flank of South Jennings dome. The first well was completed for a very small oil potential in *Heterostegina* (Oligocene) sand at 9,120 feet on August 2, 1940. The area does not look promising.

Stella, a new discovery in Plaquemines Parish, resulted from reflection-seismic work by The California Company in 1938. The discovery well, Delta Minerals No. 1, was completed in Miocene sand at 7,485 feet on August 11. Previous to discovery, The California Company had drilled a dry hole to a depth of 10,258 feet.

China, Jefferson Davis Parish, is a gas and distillate discovery by Union Sulphur Company. Their Calcasieu Bank No. 1-A was completed during September in *Marginulina*-Frio sand at 9,300 feet. It is too early to offer predictions as to the potentialities of the prospect.

Lake Salvador, St. Charles Parish.—This prospect was outlined by geophysics a number of years ago but it has seen the first development during 1940. The available information indicates that the dome is large, with a major amount of closure.

The discovery well, The Texas Company's State No. 1, was drilled during the summer and is reported to have encountered several thick saturated sands in the Miocene. It was completed, producing 840 barrels daily through $\frac{1}{4}$-inch choke at 9,775 feet. A second good well was completed during November in a new sand at 10,115 feet.

While definite appraisal can not be offered at this time, it is possible that the field may compare favorably with Lafitte and it might well be the most important new area located during the year.

South Crowley.—This prospect was classified as a new discovery in 1938, but was subsequently dropped when the discovery well failed to hold up. The completion by the Humble during September, 1940, of a good well in the Miocene, makes it possible to again classify the area as an oil field. The Leger No. 1 encountered several promising sands and was completed at 7,612 feet. This test is the ninth for the area, as four deep dry holes were drilled prior to the first discovery and three subsequent to it.

The prospect was found in 1934 with the torsion balance. A considerable amount of uplift is represented and there is evidence of a major fault that lies between the first discovery well and the present well.

West Bay.—This fifteenth discovery for coastal Louisiana for the year 1940 is located in Plaquemines Parish. The discovery well, the Gulf Oil Corporation's Timolat No. 1-B, found good commercial production in Miocene sand at 7,267 feet during the month of December. The West Bay prospect was located by reflection seismograph during 1938 and Gulf drilled one 10,000-foot failure prior to the present discovery test.

Section 28, St. Martin Parish, is a piercement dome that was recognized as early as 1917 by means of surface geological study. It has been under development intermittently for the past 20 years but commercial production was first obtained during December, 1940, by the Superior Oil Company of California. Located on the north flank, Stuart No. 1 was completed as a gas and distillate well in Miocene sand at 5,302 feet.

IMPROVEMENTS WITHIN ESTABLISHED FIELDS

Of far more immediate interest than the 16 new coastal Louisiana discoveries, is the spectacular improvement in the reserve status of numerous old productive areas. Although it is too early to advance a definite figure, it is not improbable that these improvements in areas of established production will total in excess of a hundred million barrels for 1940.

Outstanding among the areas in which new productive zones were found are *Iowa*, Calcasieu Parish, *Golden Meadows*, Lafourche Parish, *Barataria*, Jefferson Parish, and *Caillou Island*, Terrebonne Parish. At Iowa, a new series of sands below the regular pay zone, between depths of 7,500 and 8,750 feet, give a substantial increase to the known reserves of this 10-year old field. At Golden Meadows, new sands and lateral extension of known sands have greatly increased the productive area and the known reserves of this pool. It is reported that a recent deep test cored 23 separate oil and gas sands. Development at Barataria resulted in the discovery of new sands both at shallower and at greater depths than previously established production, while at Caillou Island, well developed deep sands were proved for production.

Flank development resulted in important improvements in numerous areas. At *Leeville*, Lafourche Parish, a well on the west flank is reported to have logged approximately 300 feet of saturation above 9,000 feet.

Flank development has been unusually successful during the current period. Prolific production was recovered on the flanks of *East* and *West Hackberry* in Frio sands at depths as great as 9,000 feet. At *Anse La Butte*, St. Martin Parish, good flank production was opened around the south half of the dome. The reserve position of *Jennings*, Acadia Parish, *Bayou Blue*, Iberville Parish, *Venice*, Plaquemines Parish, and *New Iberia*, Iberia Parish, was considerably improved by flank development. *Paradis*, St. Charles Parish, regarded in advance estimates as the outstanding discovery of 1939, lived up to expectations, whereas *Gibson*, Terrebonne Parish, which has been somewhat of a disappointment, reëstablished itself as a first class pool through broad southward extensions to the productive area.

WILCOX TREND

Activities along the Wicox Trend, which follows the inner margin of the coast from the Mississippi River, southwestward to the Laredo district, have failed to meet with the success anticipated in 1938. In the territory under consideration, development during 1940 resulted in the discovery of two new oil fields: *Sheridan*, Colorado County, and

Neale, Beauregard Parish. A great deal of interest has been aroused over the successful development of new Wilcox production in central Louisiana, at Olla and Jena. There is a widespread belief that this trend of updip oil may extend westward across Louisiana into Texas, particularly affecting such East Texas counties as Sabine, Angelina, Trinity, and Madison. Considerable conflict of opinion exists regarding the type of structure at Olla and Jena but it is certain that closure, if present, is of a very low order of relief. It is probable that lensing and minor strike faulting are the predominant factors in effecting closure, and this would indicate that elsewhere along this trend commercial deposits will be difficult to locate. It should be pointed out, however, that the updip Wilcox sand facies constitutes a much more desirable reservoir rock than the downdip equivalent that is productive on the coast and possibilities are sufficiently encouraging to guarantee this strip of territory a considerable future period of diligent exploration.

AREAS UNDER EXPLORATION

There has been little change during the past year in the plan of campaign designed to locate new oil pools. Except for an intensified search for Wilcox oil, most efforts have been directed toward the isolation of traps of lower relief by means of a refined geophysical technique. In Louisiana, most of the new discoveries have resulted from testing anomalies that have been recognized as such for a period of years.

The industry has been phenomenally successful in developing prolific flank sands and in uncovering deeper sands on old domes during the past several years, and this will continue to be one of the most profitable types of operation in the future.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1016-1023, 2 FIGS.

DEVELOPMENTS IN MISSISSIPPI IN 1940[1]

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ABSTRACT

Development in Mississippi during 1940 passed through two phases. The first was hysterical resulting from the fact that only a few of the major companies and independent operators had scientific data or lease protection prior to the discovery of Tinsley. This resulted in rapid and necessarily sketchy geophysical work, promiscuous leasing, and drilling of wells by crews largely inexperienced in Gulf coastal formations. The second phase was marked by a slowing of all activities and many of the smaller companies and independents became discouraged and withdrew from the state. Hasty haphazard work gave way to sounder practices in both exploration and drilling and the final play has been characterized by sanity.

During the first half of the year leasing activity was largely in the north portion of the state but during the later months the play shifted to the south.

On January 1, 1940, there were 1,221,412 acres owned by major and large independent oil companies. At the end of the year this figure increased to 4,775,619 acres, making a total of 3,554,207 acres leased during the year. If acreage owned by individuals and small independents is added to this figure it is probable that approximately 5 million acres were leased during 1940.

On January 1, 1940, there were sixty-one geophysical parties operating in Mississippi. This number was increased to sixty-four on June 1, and decreased to twenty-two parties on the last day of the year. At the peak the greatest concentration of geophysical parties in the United States was located in the state.

No new discoveries of importance were made; the Pickens field with four producers, was disappointing; the Tinsley field spread beyond early expectations with 101 producing wells. The production for Tinsley was 4,208,021.43 barrels and Pickens 286,256 barrels, making a total of 4,494,277.43 barrels for the state.

Of the 208 wells drilled, 103 were dry holes and of the latter only seven resulted in positive proof of the existence of structure. Many of the dry holes drilled were financed without any geophysical work or any geological evidence whatever, some were located on geophysical evidence which was unsatisfactory, and others were drilled on seemingly good prospects which were disproved by drilling. It is generally agreed that many of this later type were drilled on prospects where the geophysical work had been done too rapidly.

One of the main purposes of this paper is to evaluate the results outlined here and to point out their influence on future activity. Although the results of exploration during the year 1940 were disappointing a true evaluation leads to the conclusion that the state has not had a fair test, especially in the southern part, and that the future as an oil-producing area has not been materially changed. Toward the end of the year all work was moving at a slower tempo and this should benefit the quality and reliability of the geophysical work. The trend was toward more careful work with more emphasis placed on geological research and a closer correlation between the two. Sufficient time had not elapsed to obtain results from this but the coming years should prove the wisdom of this change in procedure.

INTRODUCTION

This is the first development paper devoted exclusively to Mississippi. The need for such a report has resulted from the discovery of the Tinsley field and the growing importance of the State as a future reserve area; also this outpost field points the way to the exploration of the whole Gulf coastal area of the southeastern United States. In addi-

[1] Read before the Association at Houston, April 2, 1941. Manuscript received, March 28, 1941.

[2] Consulting geologist, Tower Building.

tion it is now necessary to review all activities to date and draw conclusions which can aid in charting future policies.

Historically, development in the state passed through two phases during 1940. The first of these was a wild play reminiscent of those attending discoveries in the past. This resulted from several factors. A small minority of the major companies and even fewer of the independents had seriously worked the state; a few of these had followed up scientific work with leasing but others had only gathered the information for future reference. The addition of Mississippi to the producing states found most of the companies without protection acreage and geological information, and this situation caused hundreds to come into the state faced with the problem of making a rapid play as intelligently as the circumstances permitted. Speed was demanded in all phases of work and blocks were taken wholesale and turned without difficulty. Geophysical crews were put to work with the idea of covering the largest area in the least possible time. Most of the wells were drilled as rapidly as possible with a minimum of coring.

The second phase was entered during the last months of the year and was marked by a slowing of drilling, leasing, and geophysical work, and the withdrawal from the state of practically all of the independent and small operators. It is significant that none of the major companies withdrew but on the contrary they increased their geological staffs at the same time that all other types of work were being curtailed. The last months of the year were characterized by a return to sanity and to sound practices, in exploration and development. It is the purpose of this paper to review the activities of 1940, and evaluate them, in the light of results obtained.

LEASING ACTIVITY

The major part of the leasing activity was in the northern portion of the state and numerous lease blocks of various kinds were taken in addition to much checkerboard acreage. This was largely due to three causes: (1) the proximity of this area to the Tinsley field; (2) there had been very little leasing in the northern part of the state prior to the discovery of Tinsley, making it easier to lease large blocks, whereas approximately 70 blocks and additional checkerboard acreage had been taken in the southern counties; (3) the producing formations at Tinsley could be reached at a much shallower drilling depth than in south Mississippi. The first leases taken carried low rentals and were long term, but as the play progressed the bonus price and rental terms were raised. It is estimated that at least 5 million acres were leased during the year; 3,554,207 acres were leased by the major and large

independent companies, the remainder being distributed among the small independents and individuals. Much of the acreage held by the latter group was transferred to the large companies late in the year so that the total figure is only an approximation.

During the last six months of 1940 the play shifted to south Mississippi. This section had received the most attention prior to the discovery of Tinsley but was deserted as the play developed in the north. Sufficient geophysical work was done in the southern area late in the year to prove there were prospects in addition to those already found with a consequent renewal of activity. In many cases the surveys indicated that the structures were near the edge or even outside of the blocks as they were leased on the basis of the first work, so that blocks were enlarged or new ones taken between the old.

Large tracts of cut-over lands owned by the lumber companies were optioned for geophysical exploration and it was found that in many cases there were good prospects that had been overlooked by previous surveys.

GEOPHYSICAL ACTIVITY

The state was the center of the most intensive geophysical play of comparable areas in the United States. A casual study of the geological section led to the belief that it would be a simple problem to obtain results from all types of work and the need for speed in the play resulted in bringing in parties from all parts of the country. Herewith is a schedule showing the number and classification of such parties for each month during the year.

GEOPHYSICAL CREWS IN MISSISSIPPI, 1940

Month	*Seismograph*	*Gravity*	*Magnetometer*	*Misc.*	*Total*
January	27	30	3	1	61
February	26	31	4	1	63
March	21	34	4	0	59
April	23	30	5	1	59
May	26	29	4	1	60
June	27	36	1	0	64
July	30	35	3	0	68
August	28	28	2	0	58
September	30	22	2	0	54
October	25	16	2	0	43
November	20	14	0	0	54
December	17	10	1	0	28
Last Week of Year 1940					
	15	6	1	0	22

At the end of the year geophysicists in general were in somewhat of a quandary about the results obtained; this was especially true of those who were interpreting seismic records since the correlation of seemingly good reflections had proved erroneous. The situation was fur-

ther complicated by the fact that distinct lithological breaks did not reflect consistently. Additional information on this point will be covered in an interpretation of drilling results.

NEW DISCOVERIES

The record of new discoveries for the year was disappointing, the only new production added being the Pickens field in Yazoo County. Until outlined by drilling it gave promise of being an important field but at the end of the year there were only four producers with small chance of further expansion. However, these four wells produced more oil than the total estimated yield as forecast by most engineers at the time of their completion and produced 286,256 barrels of 43° gravity oil between April 1 and December 31. The producing sand is in the upper part of the Eutaw formation of Upper Cretaceous age.

PRODUCTION OF OIL, PICKENS FIELD, YAZOO COUNTY, 1940

Month	*Number of Wells*	*Barrels*	*Runs*
April	1	7,196	5,349
May	2	20,618	20,727
June	4	32,239	30,769
July	4	31,589	32,366
August	4	43,474	44,376
September	4	43,468	42,700
October	4	39,723	40,128
November	4	35,293	35,949
December	4	32,656	32,093
Field total	4	286,256	284,457

TINSLEY DEVELOPMENT

The development of the Tinsley field was one of the most orderly in the history of the industry and was unique in this respect. An agreement requiring 40-acre spacing was maintained and this, together with the limited market, automatically regulated production without any drastic proration being necessary. Wells drilled during the year carried the limits of production beyond all early expectations and suggest that they may be extended even farther. There were 101 producers drilled in the field and 10 dry holes.

Production figures by months were as follows.

PRODUCTION OF OIL, TINSLEY FIELD, YAZOO COUNTY, 1940

Month	*Barrels*	*Month*	*Barrels*
January	123,010.27	July	263,088.48
February	186,545.48	August	556,754.71
March	243,544.16	September	740,565.63
April	218,124.51	October	455,050.28
May	257,313.70	November	424,965.86
June	276,860.78	December	462,197.57
		Field total	4,208,021.43

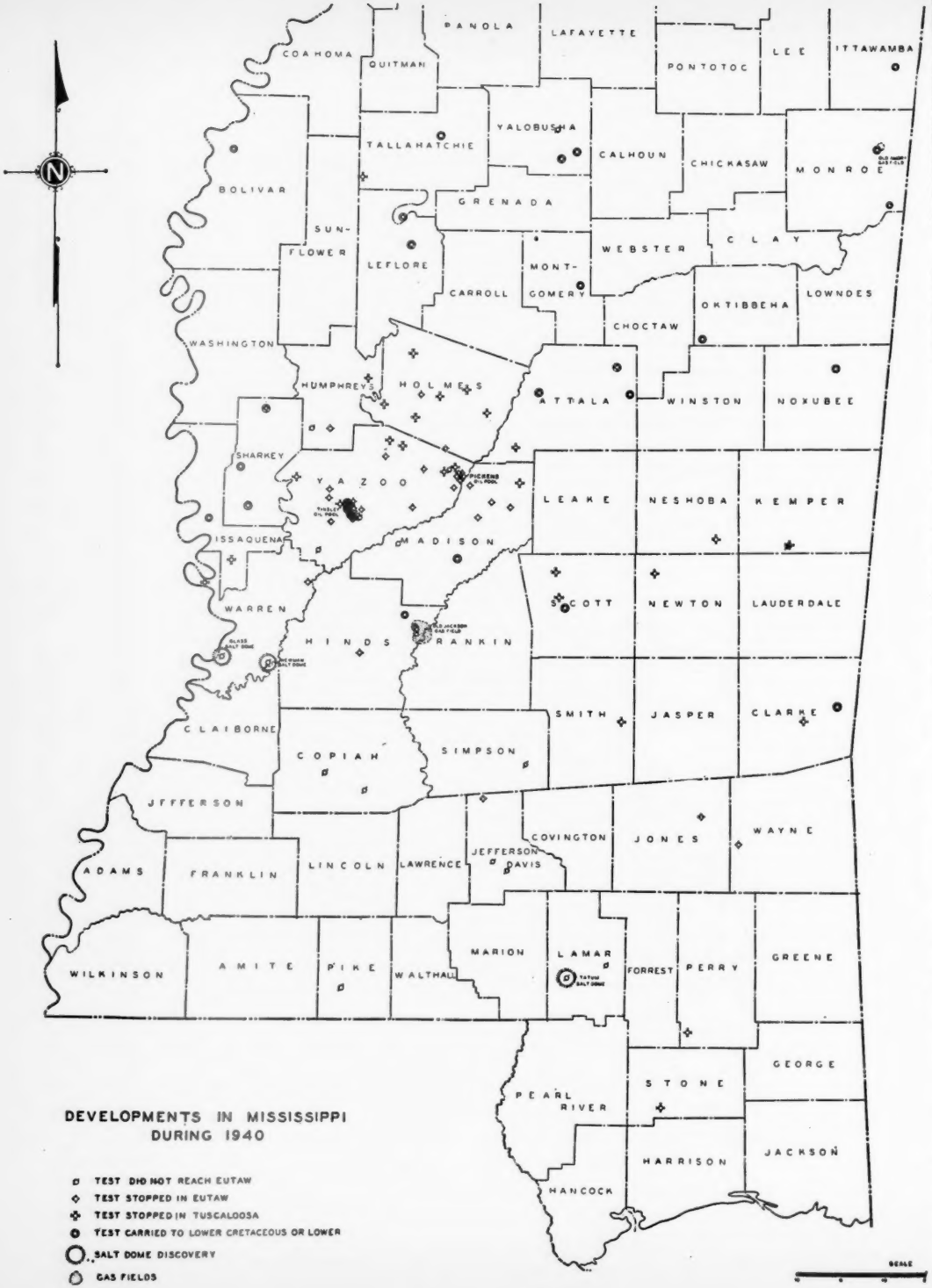


FIG. 1.—Tinsley field development during 1940.

The total production for the state amounted to 4,494,277.43 barrels.

DRILLING ACTIVITY

During the year 208 wells were drilled; the following table lists and classifies these showing the basis on which all locations were made. All water wells and those which started drilling operations but stopped after setting surface casing have been omitted.

PRODUCING WELLS

Tinsley field (surface geology)	101
Pickens field (seismograph)	4
	105

DRY HOLES

Location Method

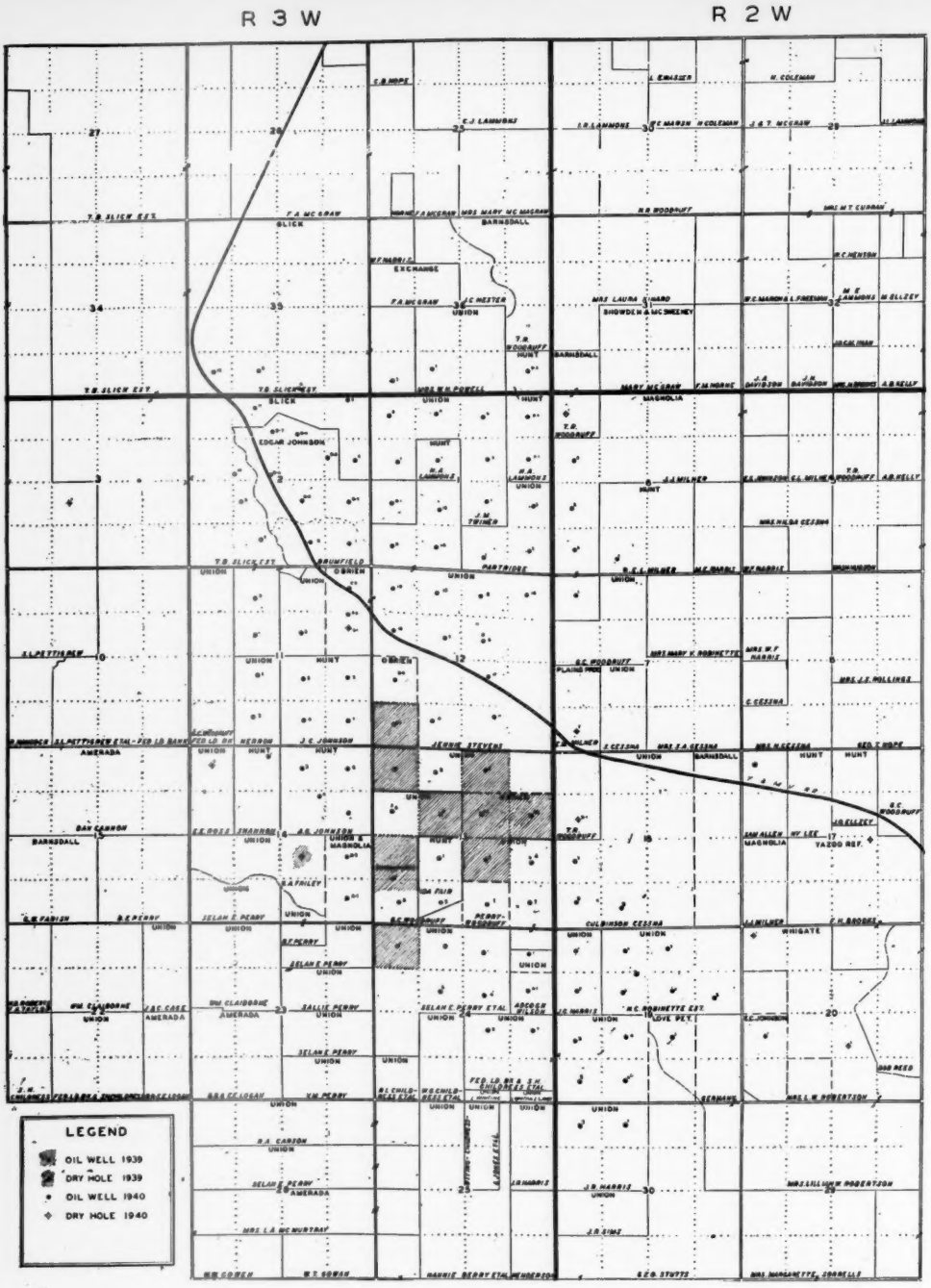
Gravity and seismograph	8
Gravity	7
Seismograph	16
Surface geology	11
Surface geology and seismograph	1
Core drill	1
Lease block	24
Showing of oil	1
Magnetometer	5
Subsurface	3
Lease block and subsurface	1
Near producing oil and gas fields	19
Abandoned gas field	2
Unknown	4
	103
Total wells drilled	208

Deducting the number of wells drilled on or adjacent to Tinsley, Pickens, the Jackson gas field, and the old Amory gas field, there were 92 dry holes completed for some one of the reasons previously given. It is very significant that only seven of these tests resulted in conclusive proof of the presence of structure, three of which were salt domes. The following list shows the proved structures and the type of work responsible for their discovery.

Pickens field	Seismograph
Glass dome in Sec. 6, T. 14 N., R. 3 W.	Surface geology
Newman dome, Sec. 12, T. 14 N., R. 4 W.	Seismograph and gravity
Montgomery County "high," Sec. 22, T. 19 N., R. 7 E.	Surface geology
Scott County nose, Sec. 5, T. 6 N., R. 7 E.	Seismograph
Jefferson Davis "high," Sec. 10, T. 9 N., R. 19 W.	Gravity
Tatum dome, Sec. 14, T. 2 N., R. 16 W.	Seismograph and surface indications

ANALYSIS OF DRILLING RESULTS

To evaluate correctly the results of the drilling of the year it is necessary to study them in the light of methods of work, reliability of work, time spent, state of knowledge of the area on which to base in-



TINSLEY OIL FIELD

YAZOO COUNTY, MISS

SHOWING DEVELOPMENT DURING 1940

FIG. 2.—Wells drilled in Mississippi in 1940.

terpretations of results, *et cetera*. There should be some good reason why only seven structures were found as the result of drilling 92 wells, 64 of which were located with the aid of geology or geophysics. It seems that the cause was largely the lack of knowledge of the fundamentals of the geologic problems involved. The following factors were contributory: (1) nearly 40 per cent of the wells were drilled without previous work of any kind; they were drilled *in lieu* of a bonus or in some cases because it was possible to finance them easily; (2) a large part of the geophysical work was done hastily without allowing the crews to do thorough work; in some cases the parties were so pushed for time that they were required to turn in results which would not even be considered adequate reconnaissance work in the older oil-producing states; some operators accepted work of this nature and drilled on it whereas they would have turned down such results in any other area, (3) the application of a set of values brought in from other areas caused confusion in interpretation; during the past year experience has developed a new set of values applicable to Mississippi; (4) on the whole, wells were more poorly drilled and logged than in the years preceding the discovery of Tinsley, but this situation was saved in part by the excellent results of electrical logging.

Not all the results have been negative for much has been gained. New subsurface data were contributed, making it possible to revise correlations of old wells which are adjacent to wells electrically logged. Possibly one of the most valuable lessons learned is the fact that the state is not easy to work and this has resulted in a changed attitude. It may be said that the predominant note at the end of the year was one of research and it is significant that of approximately forty new members added to the Mississippi Geological Society since last May, a majority are major company geologists.

CONCLUSION

The work during the coming year both in north Mississippi and in the southern part of the state will have a better chance of success as the wells to be drilled will be located on work done in the latter part of 1940 and consequently on more reliable information; on the whole the wells will be more capably handled as major companies will be drilling or a least supervising the work. In light of these facts the record of dry holes drilled during 1940 hurts the state very little, but shows the necessity of using the same care and hard work that always have been necessary in the older producing areas.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1024-1036, 4 FIGS.

DEVELOPMENTS IN SOUTHERN ARKANSAS AND NORTHERN LOUISIANA DURING 1940[1]

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ABSTRACT

Annual oil production for this area during 1940 increased by 3,546,270 barrels, or 7.6 per cent over the figure of the previous year. South Arkansas produced 25,790,380 barrels and North Louisiana 24,381,760 barrels, making a total of 50,172,140 barrels.

Of the 169 wells drilled in southern Arkansas, 53 were dry; 131 of the 651 North Louisiana wells were dry. Most of the wells in southern Arkansas were drilled to the Smackover formation, with the Hosston formation a close second. In northern Louisiana a great majority of the wells ended in the Gulf series, while the majority of the remaining wells ended in the Eocene series. Prospecting and development in southern Arkansas continued to point to the Smackover formation, while in northern Louisiana the search for Wilcox production predominated.

Southern Arkansas had one new gas-distillate field producing from the Smackover limestone, a new oil field producing from the Paluxy formation, and one producing from the Hosston formation. Northern Louisiana had two new oil fields and two new gas fields producing from the Wilcox formation, and one gas field in the Paluxy. A new field from the Hosston was in prospect at the end of the year.

PRODUCTION

Southern Arkansas produced nearly 4½ million barrels more during 1940 than in 1939. North Louisiana produced about 850,000 barrels less during 1940 than in 1939. The increase of production in South Arkansas was mostly due to the fully developed Magnolia field, and to a lesser degree, to development in several minor fields. Yearly production for both areas is shown graphically in Figures 1 and 2. New discoveries are usually followed by flush production peaks. Production for the past 2 years is as follows.

	1939 (Barrels)	*1940 (Barrels)*	*Accumulated (Barrels)*	*Number of Wells*
Arkansas	21,376,230	25,790,380	527,359,685	2,905
Louisiana	25,249,640	24,381,760	534,262,760	5,557
	46,625,870	50,172,140	1,061,622,445	8,462

Altogether, 834 wells were drilled during 1940 in both areas. The 170 wells in South Arkansas include 53 dry holes. Of the 665 North Louisiana wells, 139 were dry.

TREND OF PROSPECTING

The majority of tests in southern Arkansas have been in search of Smackover limestone production. In North Louisiana the largest num-

[1] This article was prepared with the permission of C. O. Stark and D. E. Lounsbery, Phillips Petroleum Company, Bartlesville, Oklahoma. Manuscript received, March 28, 1941.

[2] Geologist, Phillips Petroleum Company.

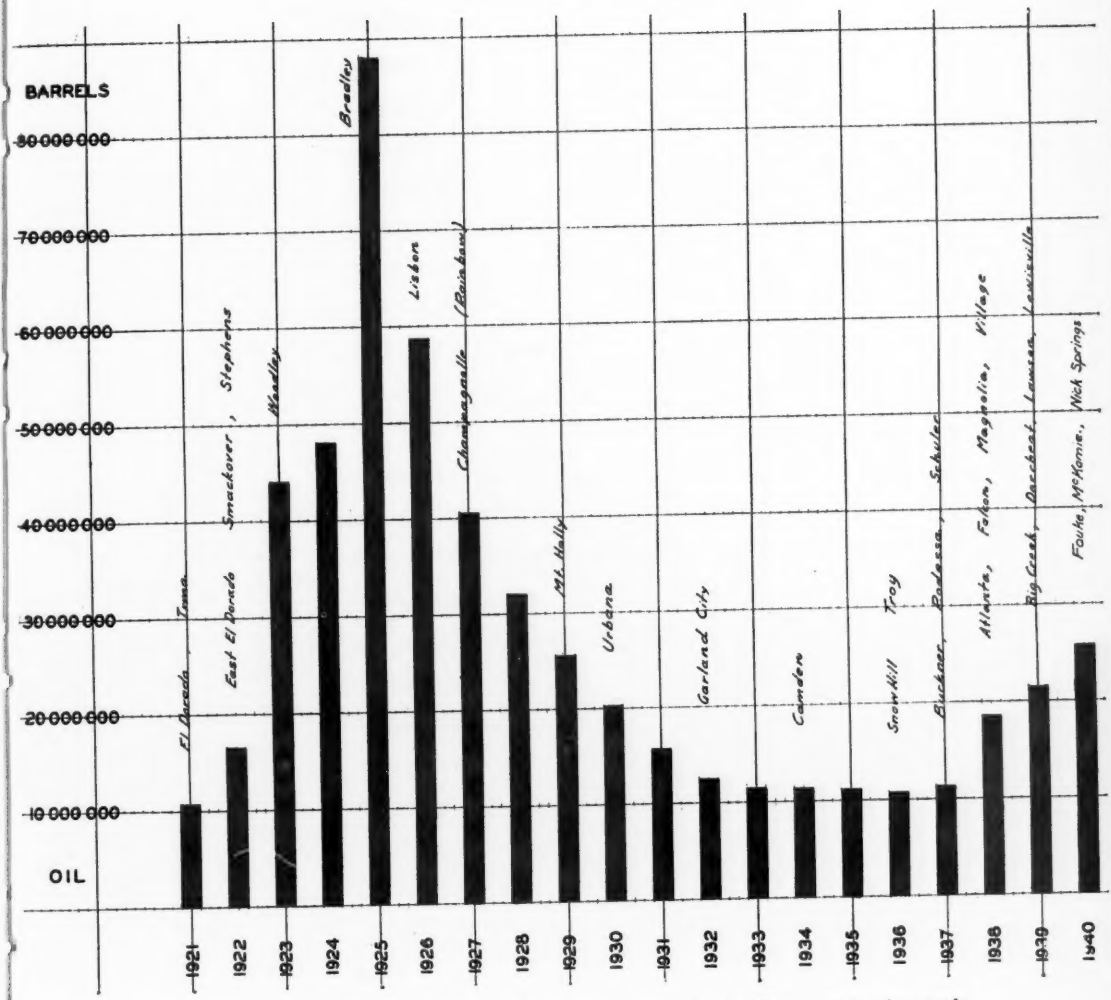


FIG. 1.—Yearly production in southern Arkansas, showing discovery of various pools.

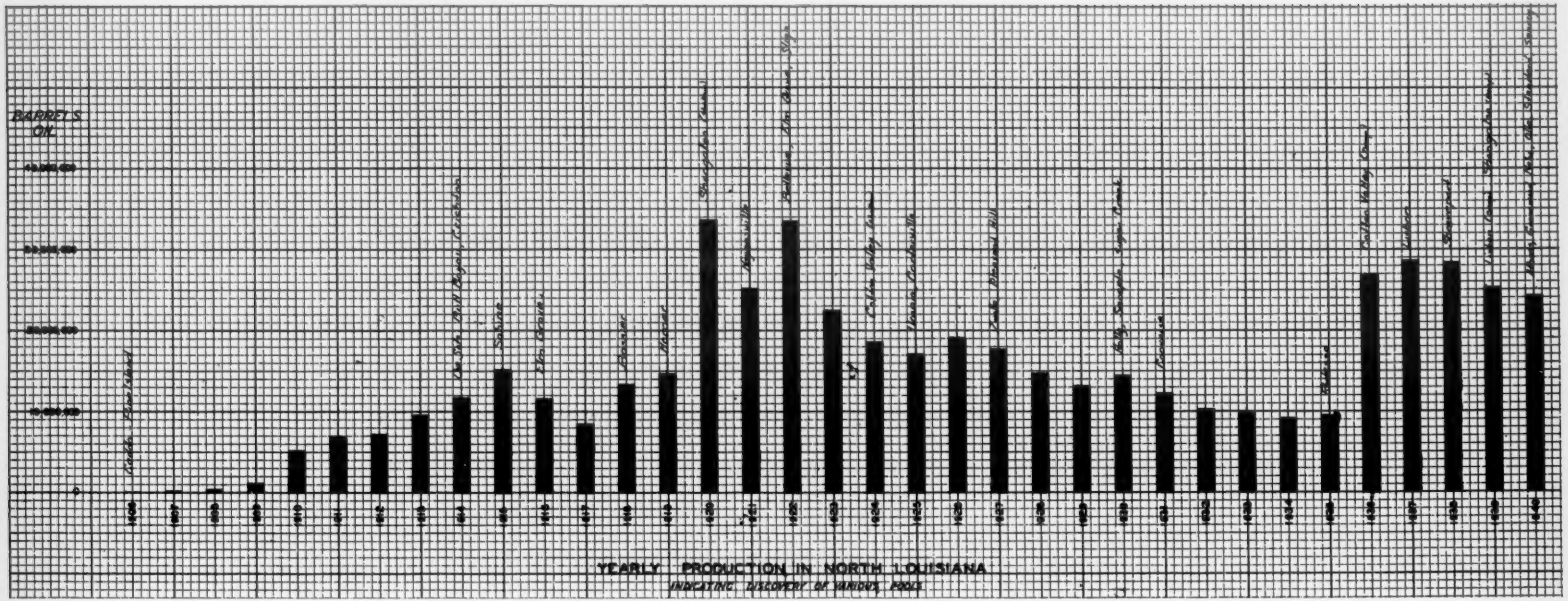


FIG. 2.—Yearly production in northern Louisiana, showing discovery of various pools.

TABLE I

ANALYSES OF PRODUCERS AND DRY HOLES DRILLED IN SOUTHERN ARKANSAS AND NORTHERN LOUISIANA DURING 1940

		Proved Fields	*Wildcats*
Number oil wells completed	Arkansas	111	3
	Louisiana	449	2
Number gas wells completed	Arkansas	2	0
	Louisiana	71	3
Number dry holes completed	Arkansas	18	35
	Louisiana	76	55
Number wells drilling at end of 1940	Arkansas	16	21
	Louisiana	85	30
(Not including 9 injection wells drilled in Louisiana)			

ber of tests has been to the Gulf series. This is due to considerable redrilling in the old Caddo field. The largest number of wildcats were tested to the Eocene formation. This was due to the new discoveries of Wilcox producing beds. Table II is an analysis of wildcat wells, indicating the deepest beds tested.

TABLE II

DEEPEST FORMATIONS TESTED BY WILDCAT WELLS DRILLED IN SOUTH ARKANSAS AND NORTH LOUISIANA IN 1940

	Arkansas	*Louisiana*
Tertiary	—	25
Gulf	4	6
Comanche		
Washita, Fredericksburg	—	1
Paluxy	2	13
Glen Rose	2	5
Hosston	9	6
Jurassic (?)		
Cotton Valley	—	1
Smackover limestone	9	1
Salt, Eagle Mills, Morehouse	2	1
Paleozoic	7	—
Igneous	—	1

Fewer geophysical crews were active during 1940 than during 1939 in southern Arkansas. Fifteen companies carried on seismograph work for short periods of time. In addition, some magnetometer and gravitymeter work was done in the area. Until the discovery of Wilcox production in LaSalle Parish, Louisiana, geophysical activity in North Louisiana was probably at its lowest in years. With the opening of the Olla field, a concentration of geophysical work followed in the shallow Wilcox trend.

Table III shows important dry holes and tests drilled in southern

Arkansas and northern Louisiana during 1940. The tests are important in that they have established or extended the limits of producing formations, in Arkansas mainly of the Smackover limestone, in Louisiana of the Cotton Valley and Hosston formations.

TABLE III

IMPORTANT DRY HOLES AND TESTS DRILLED IN SOUTH ARKANSAS AND NORTH LOUISIANA DURING 1940

SOUTH ARKANSAS

County	*Section*	*Company*	*Lease*	*Total Depth (Feet)*	*Deepest Formation Penetrated*
Arkansas	33- 5S - 4W	J. M. Hazelwood	L. Miller	4,581	Paleozoic
Calhoun	17-15S -13W	British-American Oil	Freeman Smith Lbr. Co.	4,790	Smackover ls.
Columbia	5-19S -18W	Barnsdall Oil	El Dorado & Wesson R.R.	8,760	Smackover ls.
Columbia	24-17S -19W	J. M. Forgotson	L. M. Dendy	7,768	Smackover ls.
Columbia	12-18S -23W	Gulf Refining	N. E. Lewis	9,065	Smackover ls.
Columbia	10-18S -20W	Louark Producing	Longino *et al.*	8,405	Smackover ls.
Craighead	35-14N- 3E	Tennark, Inc.	R. M. Martin	5,092	Paleozoic
Miller	1-17S -27W	Louark Producing	Sturgis	9,550	Smackover ls *
Nevada	2-11S -21W	Coker Oil	Jones	1,300	Smackover ls.
Nevada	9-15S -22W	Texas-Canadian	Stocks	6,068	Smackover ls.
Union	36-19S -17W	Barnsdall Oil	Cameron	9,069	Smackover ls.
Union	9-17S -16W	Bradham *et al.*	Slaughter	6,821	Smackover ls.
Union	29-18S -16W	Louark Producing	Zimmerman	8,020	Smackover ls.
Union	31-17S -14W	Delta Drilling	Grace	6,819	Smackover ls.

* Deepest test in South Arkansas; plugged back and completed as producer in Paluxy.

NORTH LOUISIANA

Parish	*Section*	*Company*	*Lease*	*Total Depth (Feet)*	*Deepest Formation Penetrated*
Bienville	29-18N-16W	Hanbury *et al.*	Holston unit	7,502	Hosston
Bossier	24-16N-12W	Gulf Refining	Hodges	8,647	Cotton Valley
Caddo	14-21N-15W	Stanolind O. & G.	Dillon	11,419	Igneous
Caldwell	31-12N- 3E	Arkansas Fuel Oil	La. Central Lbr. Co.	7,538	Glen Rose
Catahoula	12- 9N- 7E	Continental Oil	Tensas Delta	9,215	Glen Rose
Catahoula	26-10N- 6E	H. L. Hunt	La. Central Lbr. Co.	4,067	Wilcox
Catahoula	39-10N- 8E	Sinclair-Prairie	Peck	6,023	Midway
Claiborne	15-23N- 8W	Ohio Oil	Taylor	11,270	Smackover ls.
Concordia	41- 8N-10E	Hughes	Pittsfield Plantation	6,800	Midway
De Soto	5-11N-14W	Hunter	Anders & LeBlanc	4,818	Glen Rose
Franklin	35-14N- 9E	H. L. Hunt	Chicago Mill & Lbr. Co.	5,413	Eutaw
LaSalle	18-10N- 3E	Placid & Arkansas Fuel	Goodpine	8,997	Glen Rose*
Madison	33-18N-12E	Gulf Refining	Sondheimer	5,545	Glen Rose
Morehouse	8-22N-14E	Union Producing	Tensas Delta	10,475	Morehouse
West Carroll	27-20N-10E	The Hunter Co.	Lee unit	3,027	Hosston

* Plugged back to Wilcox and completed as discovery well in Olla field.

Stratigraphically, the important tests were divided as follows: in Arkansas two ended in the Paleozoic, 13 in the Smackover limestone, and one in the Hosston. Of the 13 Smackover limestone tests, four resulted in new fields: one in the Smackover limestone, two in the Hosston formation, and one in the Paluxy formation. The British-American test in Sec. 17, T. 15 S., R. 13 W., Calhoun County, east of any present Smackover limestone production, lacked permeability. The Atlantic Refining Company well in Sec. 29, T. 17 S., R. 23 W., Lafayette County, opened a new gas-distillate field, the McKamie field, at a total depth of 9,221 feet. The Louark test in Sec. 1, T. 17 S., R. 27 W., Miller County, at a total depth of 9,550 feet, found the oölitic zone only slightly permeable, plugged back to the Paluxy sand section, and completed as a producer. This is the deepest test in southern Arkansas. Another dry Smackover test, the Delta well in Sec. 31, T. 17 S., R. 14 W., Union County, resulted in a new field by plugging back to the Hosston.

Of the three tests for Smackover limestone production in northern Louisiana, one ended in igneous rock, one in the Morehouse formation below the Eagle Mills salt, and one in the Smackover limestone formation. The Stanolind Dillon No. 131, in Sec. 14, T. 21 N., R. 15 W., on the Pine Island dome, drilled to a total depth of 11,419 feet, stopped in igneous rock. The Cotton Valley sands were non-productive and the Reynolds porous oölite was not developed in the Smackover formation. This well was plugged back and completed as a gas well in the Hosston. The Union Producing Company's Tensas Delta No. A1, on the north edge of the Monroe field, Morehouse Parish, was drilled to a total depth of 10,475 feet and stopped in the Morehouse formation. The upper part of the Smackover limestone was found porous and contained salt water. This well was plugged back and completed as a gas well in the "Monroe gas rock." The Ohio's Taylor No. 15, in Sec. 15, T. 23 N., R. 8 W., in the Haynesville field, Claiborne Parish, was drilled to a total depth of 11,270 feet, and stopped in the Smackover formation which was tight and non-productive. At the end of the year the Union Producing Company's Meadows No. A1, Sec. 18, T. 21 N., R. 4 W., north of the Lisbon field, Claiborne Parish, was drilling below 10,000 feet and, at this writing, is in the stage of completion as a fair gas well with a large amount of distillate from the Smackover limestone and the immediately overlying Cotton Valley sands. The Gulf's Hodges No. 20, in Sec. 24, T. 16 N., R. 20 W., in the old shallow Elm Grove field, Bossier Parish, tested the upper part of the Cotton Valley formation, found it dry, and was completed in the shallow producing zone after a plug-back. Hunter's Lee No. 1, in Sec. 27, T. 20

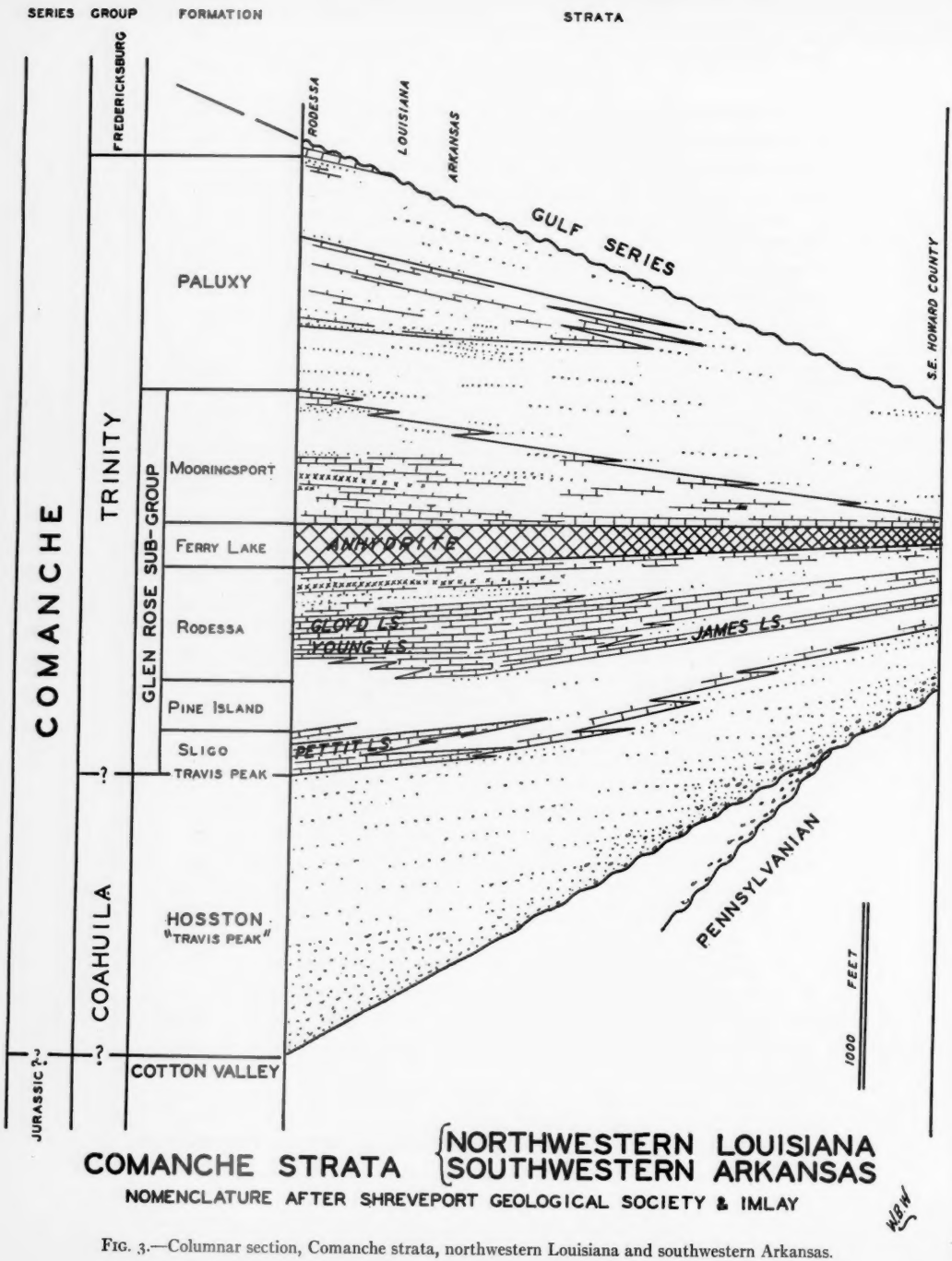


FIG. 3.—Columnar section, Comanche strata, northwestern Louisiana and southwestern Arkansas.

N., R. 10 E., in West Carroll Parish on the west flank of the Epps gas field, stopped in basal Hosston at a total depth of 3,027 feet, and was found dry.

Of outstanding interest were the wildcat tests in the Wilcox trend. Two of these wildcats were responsible for the discovery of two new oil fields; while two other wildcats opened two new areas after being completed as gas wells. The Placid Oil Company and the Arkansas Fuel Oil Company drilled their Goodpine No. 1, Sec. 18, T. 10 N., R 3 E., LaSalle Parish, to 8,997 feet and stopped in the Glen Rose. Plugged back to the Wilcox formation, this well was completed as an oil producer and was the discovery well of the Olla field. H. L. Hunt's Goodpine No. A1, Sec. 10, T. 7 N., R. 3 E., LaSalle Parish, drilled to a total depth of 3,695 feet and completed as an oil producer in the Wilcox formation, was the discovery well of the Nebo field. The Peterson Petroleum Company drilled a test in Sec. 25, T. 9 N.,R. 2 E., LaSalle Parish, to a total depth of 4,020 feet and completed it as a gas well, opening the Searcy field. Another field, the Standard, to date producing gas only, was discovered by the drilling of the Placid's Louisiana Central No. 17 in Sec. 19, T. 11 N., R. 3 E., to a depth of 5,097 feet, in the Upper Cretaceous, subsequently plugged back to the Wilcox and completed as a gas well.

The Arkansas Fuel Oil Company drilled a test to a total depth of 7,538 feet, in Sec. 31, T. 12 N., R. 3 E., Caldwell Parish, which stopped in the upper Glen Rose, was found dry, and was abandoned. The Gulf Refining Company's Sondheimer No. 1, Sec. 33, T. 18 N., R. 12 E., Madison Parish, drilled to a total depth of 5,545 feet, and reached the lower Glen Rose, which was found dry. This test added considerable knowledge to the paleogeographic information, especially that of the Glen Rose of northern Louisiana.

The Shreveport Geological Society is conducting studies toward the more complete correlation of the subsurface strata of the area. Subsurface terminology for the Comanche series was more clearly organized and set forth early in 1940. This terminology was later published by Imlay[3] in his comprehensive paper on the Comanche and Jurassic strata of southern Arkansas. Figure 3 is a columnar section showing the proposed grouping of formation names for the subsurface Comanche of this area.

NEW FIELDS

Figure 4 is an index map showing the location of oil and gas fields in southern Arkansas and northern Louisiana, and indicating the 1940 discoveries. These discoveries are listed in Table IV.

[3] Ralph W. Imlay, "Lower Cretaceous and Jurassic Formations of Southern Arkansas and Their Oil and Gas Possibilities," *Arkansas Geol. Survey Information Cir. 12* (1940).

TABLE IV

DISCOVERY WELLS DRILLED IN SOUTH ARKANSAS AND NORTH LOUISIANA DURING 1940

County or Parish	*Field*	*Location*	*Company*	*Lease*	*Top Producing Zone (Feet)*	*Age Producing Zone*	*Total Depth (Feet)*	*Initial Production*		*Producing Choke (Inches)*
								Oil Barrels per Day	*Gas Cubic Feet*	
Lafayette	McKamie	29-17S-23W	Atlantic Refining	Bodcaw Lbr. Co.	9,100	Smackover ls.	9,221	240	1,996,000	11/64
Miller	Fouke	1-17S-27W	Louark Producing	Sturgis	3,583	Paluxy	9,550	100		3/16
Union	Nick Springs	31-17S-14W	Delta Drilling	Grace	3,458	Hosston	6,819	274		1
Claiborne	Athens	31-20N- 6W	Skelly Oil	Valentine	6,316	Hosston	6,428		25,000,000	
Caddo	Greenwood	24-17N-16W	Delta Drilling	Dunn	2,543	Paluxy	2,551		3,254,000	3/4
LaSalle	Nebo	10- 7N- 3E	H. L. Hunt	Goodpine	3,353	Wilcox	3,695	48	6,000,000	16/64
LaSalle	Olla	18-10N- 3E	Placid Oil & Arkansas Fuel	Goodpine	2,267	Wilcox	8,997	264		1/4
LaSalle	Searcy	25- 9N- 2E	Peterson Petroleum	Tremont Lbr. Co.	3,160	Wilcox	4,020		12,000,000	
LaSalle	Standard	19-11N- 3E	Placid Oil	La. Central Lbr. Co.	2,475	Wilcox	5,097		20,000,000	

SOUTH ARKANSAS

Three new fields and the deeper extension of an old field were the discoveries in southern Arkansas.

McKamie.—The Atlantic Refining Company's Bodcaw Lumber Company No. 1, Sec. 29, T. 17 S., R. 23 W., Lafayette County, was completed in the Reynolds oölite of the Smackover limestone. On initial gauge the well flowed 10 barrels of 56.6° distillate per hour on 11/64-inch tubing choke with a gas-oil ratio of 8,400:1. The depth of the producing zone ranged from 9,100 to 9,206 feet. By the end of the year two other wells were completed and the field had produced 76,147 barrels of distillate. This is the farthest west of Smackover limestone in southern Arkansas, discovered as a result of seismograph work, and probably the most important discovery in that area during 1940.

Fouke.—A deep Smackover limestone test in Sec. 1, T. 17 S., R. 27 W., Miller County, the Louark Producing Company's Sturgis No. 1, was found non-productive in the Reynolds, plugged back and completed as a Paluxy sand producer. Two small wells were producing at the end of the year.

Nick Springs.—The Delta Drilling Company's Grace No. 1, Sec. 31, T. 17 S., R. 14 W., Union County, was completed on June 1, 1940, producing 16 barrels of 37° gravity oil per hour through ½-inch tubing choke from a Hosston sand at 3,465 feet. Thirteen wells were completed by the end of the year, producing from 5 sands between 3,150 and 3,760 feet.

NORTH LOUISIANA

In northern Louisiana five new fields were discovered during 1940 and one potential new field, probably a gas field, was testing at the end of the year. Of the new discoveries two were oil fields and three gas fields.

Olla.—The outstanding discovery was the Olla field, in LaSalle Parish, producing from the Wilcox formation. At the end of the year this field had 96 producers and 4 dry holes.

Nebo.—Of less importance, also producing from the Wilcox, is the Nebo field in the same parish. At the end of the year this field had 7 producers.

Standard and Searcy.—These fields in LaSalle Parish had two and one gas well, respectively, at the end of the year.

Greenwood.—This field, located in western Caddo Parish, is producing from the shallow Fredericksburg-Paluxy contact and has only one gas-well completion.

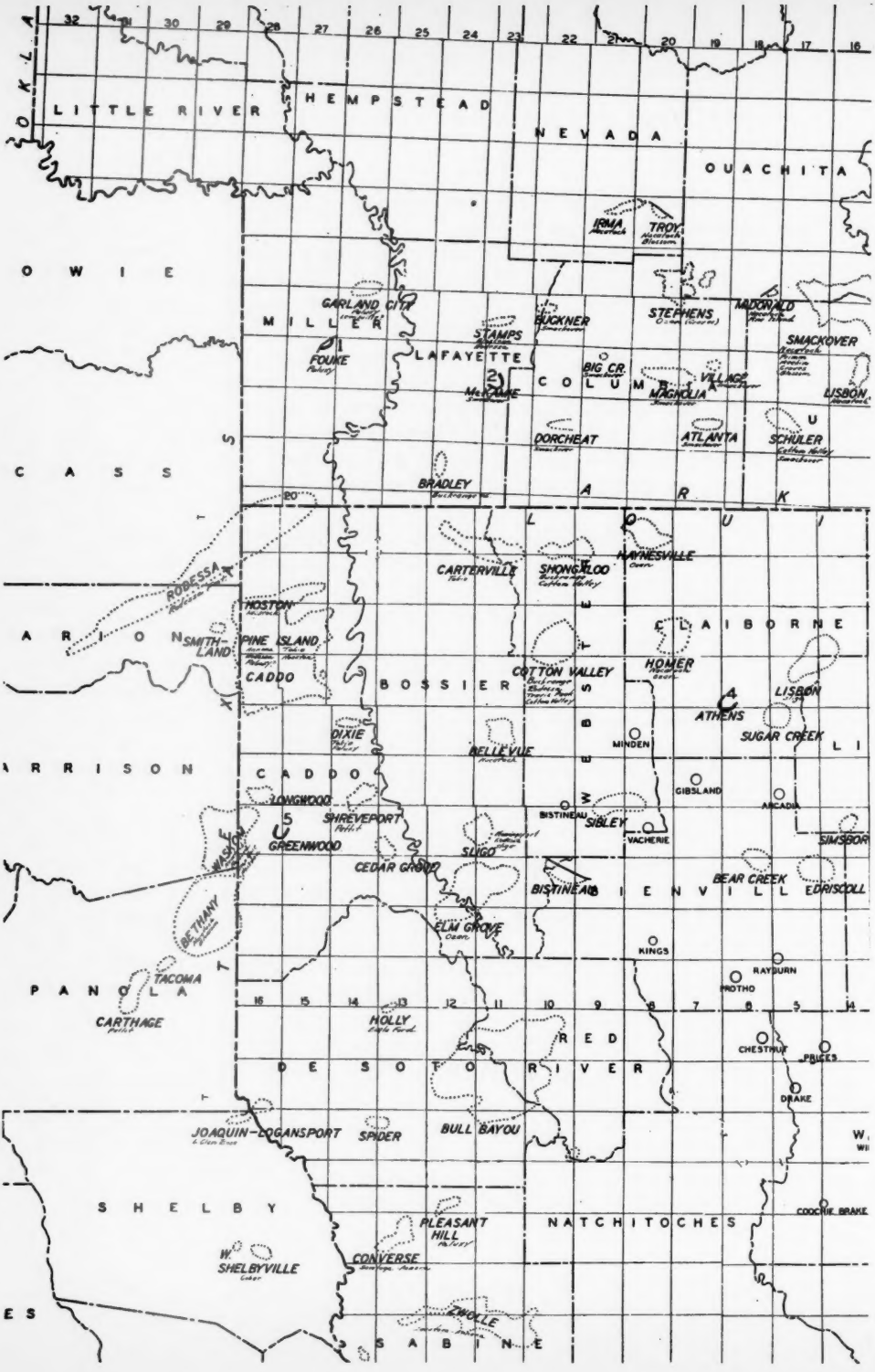
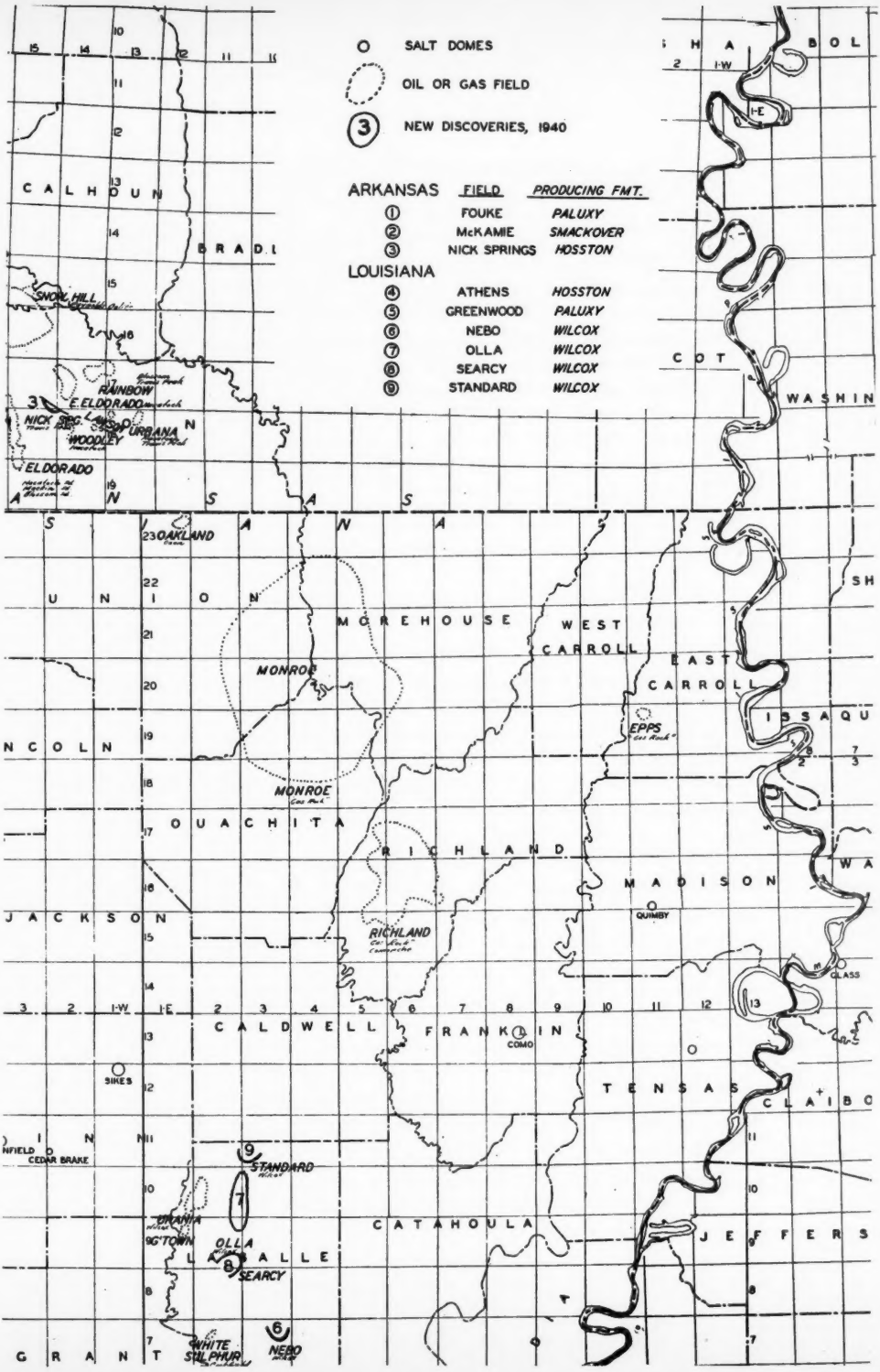


FIG. 4.—Index map, southern



Arkansas and northern Louisiana.

EXTENSIONS AND DEVELOPMENT

SOUTH ARKANSAS

Urbana.—Two new producing sands at 3,005 and 3,200 feet, in the Hosston formation, were discovered in the old Urbana pool, in Sec. 3, T. 18 S., R. 13 W., Union County, Arkansas. The original production was from a sand at 3,600 feet, within the same formation.

Magnolia.—The Magnolia field, in Columbia County, is now practically fully developed with a total of 115 wells on 4,600 acres. Thirty-three wells were drilled in this field during 1940.

Atlanta.—Atlanta had 10 oil wells and 2 dry holes drilled.

Buckner.—The Buckner field had 4 new wells.

Dorcheat.—Dorcheat, a high gas-oil ratio field, had 4 wells and a dry hole drilled during the year.

Rodessa.—The Rodessa field, Miller County, had 3 wells drilled during 1940. This field is fully developed and production is rapidly declining.

Schuler.—Schuler, by agreement of the operators, was unitized early in 1941.

SOUTH LOUISIANA

Rodessa.—In the Louisiana part of the Rodessa field, 5 wells were drilled. The production is very much on the decline.

Shreveport.—Five wells were drilled in the Shreveport field of Caddo Parish.

Sugar Creek.—The Sugar Creek gas field, Claiborne Parish, added 5 oil wells in the Hosston lenticular sand zone in the east part of the field.

Cotton Valley.—The Cotton Valley field, Webster Parish, had 14 Cotton Valley and 4 Hosston completions. The field now has a total of 120 Cotton Valley wells and 48 Hosston wells. It has been unitized in the Cotton Valley sands and a recycling plant is in progress of erection.

Lisbon.—The Lisbon field, Claiborne Parish, had originally a total of 259 wells. At the present time, 27 wells are flowing, 118 are pumping, 33 are on gas lift, 26 are dead, 42 are abandoned, and 13 are used for gas-injection wells, using gas from two deep gas-distillate wells in the Cotton Valley. Decline of production has resulted in deeper drilling and, at present, one well is producing oil from the Hosston at 5,428 feet. On the south side of the field one well was drilled to 9,016 feet and was completed as a gas-distillate well in the Cotton Valley.

Sligo, Logansport, Bistineau, and Sibley.—These Glen Rose gas fields are being developed slowly and in an orderly manner.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1037-1043, 2 FIGS.

DEVELOPMENTS IN SOUTH TEXAS DURING 1940[1]

L. B. HERRING[2]
Corpus Christi, Texas

ABSTRACT

This paper discusses the developments during the year 1940 in the South Texas area and suggests that the collapse of foreign markets caused pipe-line proration and local price cuts.

Twenty-eight new producing areas were found during the year. Drilling was slightly under the 1939 rate, and geological exploratory work was greatly reduced.

Four wildcat wells were completed in Wilcox sands: three producing gas and condensate, and one producing oil with water. None of these discoveries appears to represent reserves of consequence.

Condensate production reached 8,800 barrels per day, and nine plants were operating on a repressuring or a recycling basis.

INTRODUCTION

The South Texas petroleum area includes on the east, Jackson, Lavaca, and Fayette counties and extends north around Milam County. Thence it continues southwestward through the Llano-Burnet uplift and to the Rio Grande. The Rio Grande and the Gulf of Mexico establish its other limits.

The general area has been segregated into three provinces, based on the ages of its producing formations: (1) San Antonio or pre-Eocene producing area, (2) Laredo (including Beeville) or Eocene producing area, and (3) Corpus Christi or post-Eocene producing area.

Statistics show that the economic conditions of the petroleum industry in South Texas reflect closely the status of the oil industry in the nation as a whole. Due to its pipe-line facilities and deep-sea terminals, any abnormal strength or weakness in the Mid-Continent area, the eastern seaboard, or the world markets has an immediate and direct influence. An important influence in 1940 was the collapse of foreign markets causing pipe-line proration, below the allotted allowable, and local price cuts.

Lease situations, such as drilling obligations and expirations, determined the locations of many of the wildcats. Few, if any, of the drilled prospects could be classed as Grade A. Drilling in the San Antonio area declined perceptibly. The drilling progress in the Laredo and Corpus Christi areas was slightly less than in 1939.

The amount of exploratory geological work waned in the Corpus Christi and San Antonio areas; in the San Antonio area it amounted almost to nothing.

[1] Read before the Association at Houston, April 2, 1941. Manuscript received, March 10, 1941.

[2] Geologist, Nixon Building.

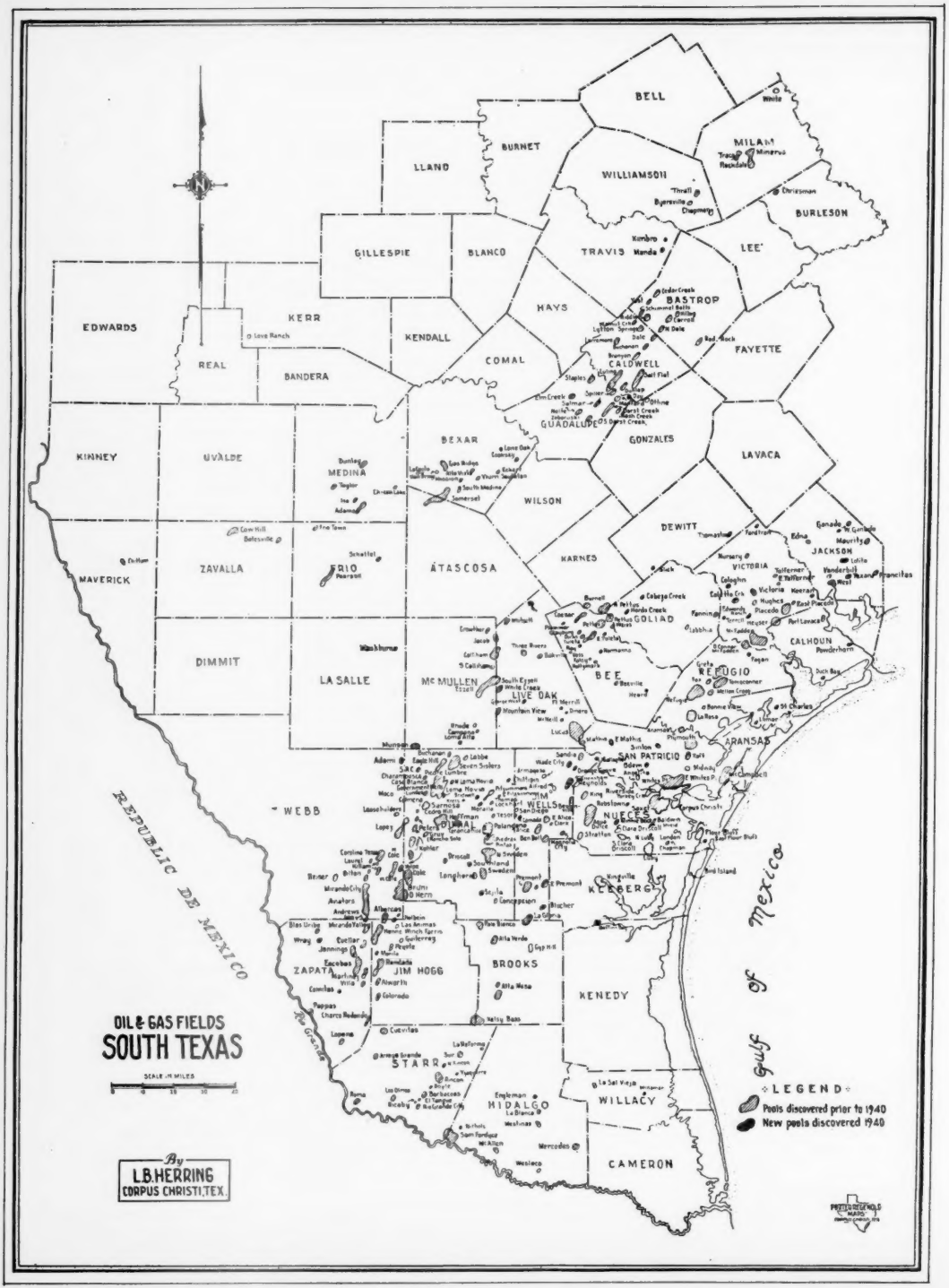

OIL & GAS FIELDS
SOUTH TEXAS
SCALE IN MILES
By
L.B. HERRING
CORPUS CHRISTI, TEX.
REPUBLIC DE MEXICO
Gulf of Mexico
LEGEND
Pools discovered prior to 1940
New pools discovered 1940
BELL
WILLIAMSON
BURNET
LLANO
MILAM
BURLESON
LEE
TRAVIS
GILLESPIE
BLANCO
HAYS
BASTROP
FAYETTE
EDWARDS
KERR
KENDALL
COMAL
CALDWELL
REAL
BANDERA
GUADALUPE
GONZALES
LAVACA
KINNEY
UVALDE
BEXAR
MEDINA
WILSON
DEWITT
JACKSON
MAVERICK
ZAVALLA
FRIO
ATASCOSA
KARNES
VICTORIA
GOLIAD
CALHOUN
DIMMIT
LA SALLE
McMULLEN
BEE
REFUGIO
LIVE OAK
ARANSAS
SAN PATRICIO
WEBB
JIM WELLS
NUECES
KLEBERG
ZAPATA
JIM HOGG
BROOKS
KENEDY
STARR
HIDALGO
WILLACY
CAMERON

FIG. 1

TABLE I

FIELDS DISCOVERED IN 1940

Field Name	*County*	*Depth of Discovery Sand in Feet*	*Producing Formation*	*District*	*Initial Production, Barrels per Day*	*Choke (Inches)*
Baffins Bay	Kleberg	7,455–7,466	Frio	Corpus Christi	136	1/4
Boyle	Starr	3,490–3,500	Frio	Corpus Christi	100	7/64
Bridwell	Duval	4,321–4,327	Pettus	Laredo	122	3/16
Day	Guadalupe	2,440–2,460	Austin chalk	San Antonio	35	Pump
Duck Bay	Calhoun	5,635–5,675	Basal Catahoula	Corpus Christi	100	3/16
Edwards Ranch	Victoria	5,036–5,041	Frio	Corpus Christi	1,500 MCF*	1/8
Fagan	Refugio	5,893–5,907	Frio	Corpus Christi	91	3/32
E. Fitzsimmons	Duval	4,901–4,916	Yegua	Laredo	11½	Pump
E. Flour Bluff	Nueces	6,779–6,800	Frio	Corpus Christi	178	1/8
Gallagher	Jim Wells	5,189–5,193 5,200–5,207	Frio	Corpus Christi	90	1/8
W. Ganado	Jackson	5,204–5,212	Frio	Corpus Christi	241	12/64
Glen	Webb	2,173–2,185	Mirando	Laredo	630	1/2
Henshaw	Jim Wells	5,133–5,144	Frio**	Corpus Christi	312	3/16
Holbein	Jim Hogg	2,795–2,810	Lower Pettus	Laredo	56	Flow valves
Kreis†	Duval	3,246–3,255	Mirando	Laredo	33	Pump
Lolita	Jackson	5,933–5,938	Frio	Corpus Christi	335	3/16
Manila	Jim Hogg	2,603–2,613½	Pettus	Laredo	85	1/4
Nichols	Hidalgo	3,481–3,502	Frio	Corpus Christi	86	9/16
Orange Grove	Jim Wells	5,087–5,102	Frio	Corpus Christi	100	1/8
North Rincon	Starr	4,127–4,137	Frio	Corpus Christi	23½	Pump
Shield	Nueces	6,603–6,657	Frio	Corpus Christi	215	5/32
St. Charles	Arkansas	?	Frio	Corpus Christi	Blew out, abandoned	None
Terrell	Victoria	5,274–5,301	Frio	Corpus Christi	35	Pump
Thomaston	Dewitt	7,778–7,830	Wilcox	Laredo	120	1/4
Washburn	La Salle	4,860–4,880	Wilcox	Laredo	114	3/18
George West	Live Oak	?	Wilcox	Laredo	70 through stuck drill stem, abandoned	
Willamar	Willacy	7,620–7,678	Frio	Corpus Christi	264	1/4
Yzaquirre	Starr	4,610–4,644	Frio	Corpus Christi	62	3/16

* Thousand cubic feet (gas).
** Base Frio in this chart placed at top of *Textularia warreni*.
† Not officially named.

DISCOVERIES

Twenty-eight new producing areas were discovered during 1940. A few of them have not received additional development and several of them have brought disappointments in subsequent drilling. Known additions to reserves amounted to very little; the most important are at (1) East Flour Bluff, Nueces County; (2) Orange Grove, Jim Wells County; and (3) Lolita, Jackson County.

Some of the major developments of the year occurred in areas previously discovered or producing. Important reserves were added at Rincon, Starr County; Colorado, Jim Hogg County; Wade City, Jim Wells County; and West Ranch, Jackson County.

Present evidence indicates that one of the most important reserves added during the last few years occurred with the discovery of crude oil along the east flanks of the Agua Dulce-Stratton gas field. This gas field which extends 14 miles and is still open toward the south contained about 120 completed gas wells before commercial oil production was added. The area began producing gas in 1927 and since then has had numerous oil showings and several high gas-oil ratio oil wells but prior to 1940 their histories were invariably so disappointing that further prospecting for oil had been discouraged.

Eight separate sands in the Agua Dulce-Stratton area have been proved to contain commercial oil reserves. The maximum number found to date in any one well is three, with a saturated oil section of 65–70 feet. The structural position of the oil reservoir is approximately 200 feet downdip from the apex of the structural axis. The two most important oil sands, known to date, have oil columns of more than 175 feet. No single oil zone is continuous over the present developed area. They pinch out both at right angles to, and parallel with, the strike of the beds. Stratigraphical pinch-outs in conjunction with structure have been the cause of part of this accumulation.

The oil zones are located, stratigraphically, in a part of the Frio or Oligocene series which has been penetrated only in scattered wells in the Corpus Christi area. Drilling has shown that these lower beds have either a complex sedimentary history, or have been subjected to complex folding, or both. The development at Agua Dulce offers an opportunity to study these problems.

The value of discoveries in the pre-Eocene or San Antonio area was the lowest in many years.

The addition of reserves in the Eocene or Laredo area was less than production and the lowest of any year since proration came into effect. The market for this crude is greater than the supply and could absorb a considerable increase.

WILCOX DEVELOPMENT

Four wildcat wells were completed in Wilcox sands, three producing gas and condensate, and one producing oil with water. Three of the discoveries were located by geophysical methods and the fourth was located on a structure previously outlined by Pettus production. None of these appears to represent reserves of any consequence; however, they are important in that they represent the first production of any type to be found in the Wilcox sands in South Texas.

These discoveries caused rapid leasing activity in which most of the property, along the strike, was leased or optioned for geophysical exploration. Surface geology and geophysical work are being used on a major scale.

One important feature of these discoveries is the wide area which they embrace and the variance of the datums at which these discoveries were found. The top of the Wilcox sand in the Washburn area, LaSalle County, is −2,770 feet and the top of the Wilcox in the George West area, Live Oak County, is −6,810 feet.

Another important feature of these discoveries is the position in the Carrizo-Wilcox section of the producing zones. All the oil has been

produced from segregated zones, down in the sand section and not at the top.

PRODUCTION

The total barrels of oil produced in South Texas in 1940 were about the same as in 1939 but the areal distribution of this production changed noticeably.

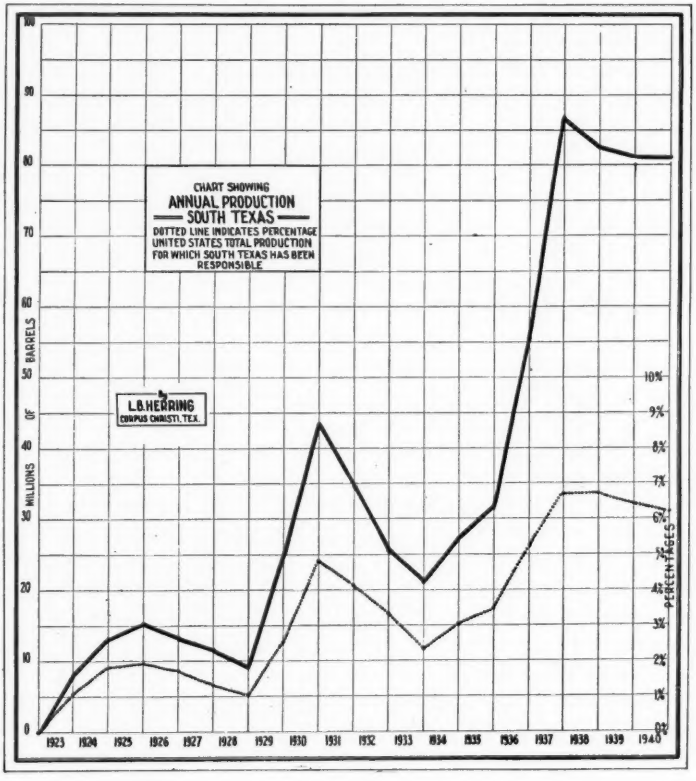


FIG. 2

The San Antonio area showed the normally anticipated decline as no important production has been developed in the last few years.

The Laredo area added no appreciable reserves, either through discoveries or extensions, but the market demand for this crude caused a slight increase in annual production.

The total production for the Corpus Christi area decreased, although several thousand barrels of daily production were added by new developments in Jackson County and the current completions of gas-recycling projects.

During the last few years an important part of the oil produced in the Corpus Christi area has been purchased by local pipe lines whose major markets were foreign. When embargoes and the war closed these outlets, production was curtailed substantially until local markets could be found.

The percentage of national production which South Texas contributed dropped, slightly, from 6.4 per cent in 1939 to 6.2 per cent in 1940.

CONDENSATE

At the end of 1940 condensate was being processed in nine major plants in which the stripped gas was returned to the producing zones. At that time this production amounted to approximately 8,800 barrels per day and required the processing of little more than 500 million cubic feet of gas. One additional plant is under construction and unless new discoveries are made, only a few more may be anticipated.

It was stated a year ago that all known gas reserves, capable of being economically processed for condensate, occurred in post-Eocene beds. Developments during the past year give evidence that the Eocene may contain gas reserves with the necessary requisites for feasible recycling projects.

Before the construction of recycling plants, consistent exploratory work was not done in most fields known to possess only gas. There were two reasons for this: (1) conservation regulations, intended to prohibit the wanton waste of natural gas in order to produce condensate, and (2) the lack of markets for natural gas. To supply these recently constructed recycling plants with gas and to scour effectively producing formations, it was necessary to drill additional wells, most of which were intentionally located near the assumed edges of gas production. This drilling has led to the discovery of crude-oil reserves greater than the known recoverable condensate reserves of South Texas. The most important rôle played by gas-recycling projects to date has been the unintentional discovery of oil accumulations which, directly or indirectly, resulted from the drilling necessary for their operations.

TECHNICAL AND SCIENTIFIC ADVANCE

In order to increase the daily gas flow per well some wells with two or more proved producing zones have been completed in two separate

zones, the lower zone producing through the tubing and the upper zone segregated by a packer, producing between the tubing and the casing. Mechanical devices have been developed which overcome the recognized impediments to this procedure and operators who are employing this method express complete satisfaction with the results. It enables one well to produce as much as two wells, each completed in the same zone. The additional cost is slight.

Electrical logs are gradually portraying the regional information on pinch-outs and strand lines of known producing sections. These logs have also given regional data on the areas of the major sand developments in known producing zones, such as the Pettus and Frio. Data have been made available through electrical logs to prove that many of the individual sands have definite patterns and in some places it is now possible to interpolate their areal extents within reasonable bounds of accuracy. This knowledge can be employed not only in determining potentialities of structures, but also in predicting the possibilities of lensing sands producing along their flanks.

The advantages of chemically treating producing sands are being appreciated more and more. In recycling projects it is necessary that wells produce and take back a maximum amount of gas. At Agua Dulce commercial gas wells have been treated and improved as much as 50 per cent. The ability of chemicals to aid wells, whose producing abilities were below economic levels, has been realized previously.

In the Pure Oil Company's Garcia Land and Livestock Company No. 1, Cameron County, the following fossils were reported: (1) *Bigenerina floridana* at 3,000 feet, (2) *Bigenerina humbleina* at 6,010 feet, and (3) *Cibicides carstensi* at 6,300 feet.

These fossils are not identical with but remarkably similar to those found in the Miocene section of southern Louisiana and described by Ellisor.[3] This was the first well in Texas to show a definite relationship between the middle and the lower Miocene of Louisiana with South Texas and suggests that a continuous belt of Miocene deposition took place out in the Gulf of Mexico from Louisiana to this area.

[3] Alva C. Ellisor, "Subsurface Miocene of Southern Louisiana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 3 (March, 1940).

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1044-1063, 2 FIGS.

DEVELOPMENTS IN WEST TEXAS AND SOUTHEASTERN NEW MEXICO DURING 1940[1]

TAYLOR COLE,[2] ROBERT I. DICKEY,[3] AND EDGAR KRAUS[4]
Midland, Texas, and Carlsbad, New Mexico

ABSTRACT

Development in West Texas continued at about the same rate as during the previous 2 years, with 1,747 field wells being completed, and 119 wildcats. The percentage of wildcat strikes was unusually high in that 47 were producers while the percentage of dry holes was only 5.6 per cent. Eighteen new discoveries (twice as many as during 1939) were recorded with fourteen from Permian rocks ranging from the Yates sand (upper Whitehorse) down to the upper part of the Clear Fork. The four pre-Permian discoveries included one each from the Lower Pennsylvanian, Silurian, Simpson (Middle Ordovician), and Ellenburger (Lower Ordovician). Five of the new discoveries are in Crockett County. Many of the fields were extended considerably, and several geologically important wildcats were drilled.

The trend in exploration seems to be toward more and deeper wildcatting with probably a slow orderly development of the new discoveries except where near-expiration leases are held.

There have been very few improvements in drilling and production practices. Activity in geophysical exploration was at a high level in the central and southern parts of the Midland basin and along the Eastern platform.

Development in southeastern New Mexico was less than the previous year with 542 wells being drilled. The percentage of dry holes (13.5 per cent) ran higher than previously because of hazardous development in lenticular, irregularly cemented "sands" flanking the Artesia-Maljamar nose on the south and north. Few deep exploratory tests were drilled in spite of contiguous areas of West Texas being productive from pre-Permian formations. Only two new discoveries were recorded from southeastern New Mexico, but several fields were extended considerably.

INTRODUCTION

A review of activities in West Texas and southeastern New Mexico during the past year reflects an increase in the number of wildcats and discoveries drilled in comparison to 1939. The trend in exploration is toward more wildcatting and deeper drilling due chiefly to discovery of new "pays" in the lower Permian, and discovery of several shallow Ordovician fields. Indications are that this will continue to be the trend for 1941.

Geological developments during 1940 included the publication of the "West Texas-New Mexico Symposium, Part I," which consists of 12 papers.[5] The four cross sections[6] discussed in four of these papers

[1] Read before the Association at Houston, April 2–4, 1941. Manuscript received, March 24, 1941.

[2] Research geologist, University Lands, Midland, Texas.

[3] Geologist, Forest Development Corporation, Midland, Texas.

[4] Geologist, Atlantic Refining Company, Carlsbad, New Mexico.

[5] "West Texas-New Mexico Symposium. Part I," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 1 (January, 1940), pp. 1–188, included the following articles.
Ronald K. DeFord and E. Russell Lloyd, "Editorial Introduction," pp. 1–14.
W. C. Fritz and James FitzGerald, Jr., "South-North Cross Section from Pecos County through Ector County, Texas, to Roosevelt County, New Mexico," pp. 15–82.

were also published separately in large-scale form; Frank E. Lewis's extensive stereograms[7] were published in the same form. Three papers[8] published in February, though concerned with the Permian in general rather than with local geology, have immediate bearing on the stratigraphy of West Texas and New Mexico and the proposed standard section in the Delaware basin. A monograph[9] on the Permian ammonoids of West Texas was published in March. Further publication included geologic notes on the Ordovician of the Apco field[10] in Pecos County, on Pennsylvanian oil from the Todd Ranch[11] in Crockett County, on Mississippian novaculite[12] in New Mexico, and on the microscopic examination[13] of Permian crude oil from West Texas and New Mexico. At the fall meeting of the West Texas Geological Society in Midland, August 17, 1940, eight geologic papers were read. Several of these will be published in 1941. The West Texas Geological Society conducted two field trips in 1940: a spring trip to the Sacramento Mountains and a fall trip to outcrops in the vicinity of Carlsbad, Eddy County, New Mexico. At the meeting of the Geological Society of

E. Hazen Woods, "South-North Cross Section from Pecos County through Winkler County, Texas, to Roosevelt County, New Mexico," pp. 29–36.

Robert I. Dickey, "Geologic Section from Fisher County through Andrews County, Texas, to Eddy County, New Mexico," pp. 37–51.

Lincoln R. Page and John Emery Adams, "Stratigraphy, Eastern Midland Basin, Texas," pp. 52–64.

M. G. Cheney, "Geology of North-Central Texas," pp. 65–118.

Elliot H. Powers, "Sand Hills Area, Crane County, Texas," pp. 119–33.

John Emery Adams, "Structural Development, Yates Area, Texas," pp. 134–42.

Philip B. King, "Older Rocks of Van Horn Region, Texas," pp. 143–56.

L. A. Nelson, "Paleozoic Stratigraphy of Franklin Mountains, West Texas," pp. 157–72.

C. E. Needham, "Correlation of Pennsylvanian Rocks of New Mexico," pp. 173–79.

John W. Skinner, "Upper Paleozoic Section of Chinati Mountains, Presidio County, Texas," pp. 180–88.

[6] DeFord and Lloyd, *op. cit.*, Fig. 3, p. 12.

[7] DeFord and Lloyd, *op. cit.*, p. 13.

[8] Carl O. Dunbar, "The Type Permian; Its Classification and Correlation," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 2 (February, 1940), pp. 237–81.

Raymond C. Moore, "Carboniferous-Permian Boundary," *ibid.*, pp. 282–336.

C. W. Tomlinson, Raymond C. Moore, Robert H. Dott, M. G. Cheney, and John Emery Adams, "Classification of Permian Rocks," *ibid.*, pp. 337–58.

[9] A. K. Miller and W. M. Furnish, "Permian Ammonoids of the Guadalupe Mountain Region and Adjacent Areas," *Geol. Soc. America Spec. Paper 26*, pp. 1–242.

[10] Taylor Cole, "Ordovician Development, Apco Structure, Pecos County, Texas," *ibid.*, Vol. 24, No. 3 (March, 1940), pp. 478–81.

[11] D. D. Christner, "Todd Ranch Discovery, Crockett County, Texas," *ibid.*, Vol. 24, No. 6 (June, 1940), pp. 1126–27.

[12] C. L. Baker, "Probable Lower Mississippian Age of the Caballos Novaculite, New Mexico," *ibid.*, Vol. 24, No. 9 (September, 1940), pp. 1679–81.

[13] Ronald K. DeFord, "Microscopic Examination of Permian Crude Oils," *ibid.*, Vol. 24, No. 12 (December, 1940), p. 2181.

America in Austin, Texas, Christmas week, 1940, the society presented an exhibit on the methods and results of subsurface geology in the Permian basin of West Texas and southeastern New Mexico.

There were very few improvements or changes in drilling and production practices during 1940.

Spacing of wells in West Texas was considerably wider than in previous years partially due to new spacing rules as ordered by the Railroad Commission establishing mathematical 20-acre spacing. The spacing rules in southeast New Mexico remained at one well to 40 acres. Proration plans adopted during 1940 in West Texas showed a tendency toward greater acreage factors and establishment of gas production limits. In New Mexico the only change in proration regulations was the adoption of gas-displacement factors for fields in Lea County.

The average depth of new wells increased, and there was an increase in the use of small-size casing and slim hole. The type of well information obtained during drilling showed improvement due to better mud control, coring and core analyses, electrical surveys, drilling-time records, temperature surveys, and bottom-hole pressure surveys. The only new surveys run were mud analysis and gamma-ray surveys.

Wells completed this year were mostly shot or acidized, the size of the shot or the amount of acid generally being larger than in past years. The practice of setting the oil string at total depth and gun perforating opposite the "pay" was initiated by some operators.

More attention was paid to efficient production methods including gas lift and efficient rate of flows to reduce gas-oil ratios. Considerable work was performed to conserve reservoir energy by the use of cement squeeze jobs, liners, formation packers, and chemical formation plugging. Five repressuring operations are active in West Texas and two in southeastern New Mexico have been proposed.

The West Texas-southeastern New Mexico area produced 117,348,873 barrels of oil of which 78,862,554 barrels were produced in West Texas and 38,486,319 barrels were produced in southeastern New Mexico.

ACKNOWLEDGMENTS

The writers wish to acknowledge the advice of the several geologists who aided in the criticism of this paper.

Jerald H. Bartley furnished drilling statistics, Ronald K. DeFord discussed geological developments, and E. H. Wahlstrom discussed petroleum-engineering developments. For these contributions the writers wish to express their gratitude.

DEVELOPMENTS IN PERMIAN OF WEST TEXAS, 1940

During 1940 the search for oil production from the Permian was carried out over all parts of the West Texas part of the Permian basin. An analysis of the wells drilled shows that, as in the past, the greatest number of wildcats and semi-wildcats, drilled mainly to explore the Permian, were located on the Central Basin platform. There were 31 wells so located. The Midland basin proper received eight tests while the north end of the basin had three and the south end seven. On the east side of the Midland basin, there were fifteen Permian tests.

NEW PERMIAN PAY ZONES

The known producing pay zones in the Permian were extended over wider areas and new areas of production found. These include the Yates sand, Seven Rivers dolomite, Queen sand, Grayburg, upper San Andres pay zone, Holt pay zone, and Tubb pay zone. In addition to these, two and possibly three new producing pay zones were discovered. In western Crockett County, the Noelke field was opened when the Soma Oil and Gas Syndicate's W. T. Noelke No. 1, in Sec. 30, Block G.G., H.E. & W.T. Survey, came in flowing a large amount of oil and gas at a total depth of 1,039 feet, from a new producing sand in the Seven Rivers formation of the Whitehorse group. The producing sand, which is locally called the Soma sand, was found from 1,028 to 1,039 feet in depth. The stratigraphic section in the discovery well of the Noelke field is as follows.

	Depth in Feet	
Cretaceous	0– 260	
Triassic	260– 425	
Permian		
Salado	425– 828	
Cowden Anhydrite member	680– 705	
Whitehorse group		
Tansill	828– 878	
Yates sand	878– 980	
Seven Rivers	980–1,032	T. D.
Soma sand	1,028–1,032	

The Soma Oil and Gas Syndicate's W. T. Noelke No. 1 flowed 441 barrels of 32.2° gravity oil in one hour on potential gauge.

B. C. Mann's Funk No. 1, in Sec. 32, Block 1, H. & T.C. Survey in northwestern Tom Green County, opened a new producing zone and new area on the Eastern platform when it was completed, flowing 61½ barrels of oil in 21½ hours, through tubing. The well was drilled to 1,562 feet where a hole full of sulphur was encountered from 1,560 to 1,562 feet. It was then plugged back to 1,160 feet and is being produced through perforations in the 5-inch casing from 1,121 to 1,129

feet after treatment with 1,000 gallons of acid. The pay zone in this well is in dolomite in the San Andres, 166 feet above the top of the San Angelo sand section. The stratigraphic section drilled in this well is as follows.

	Depth in Feet
Cretaceous	0– 330
Permian	
Whitehorse	330– 930
San Andres	930–1,422
San Angelo sand	1,287–1,422
Clear Fork	1,422–1,562 T. D.

A third possible new Permian producing pay zone, about which little is known, is that from which production is secured in Amon G. Carter's A. L. Wasson No. 5-D, in Sec. 50, Block AX, P.S.L. Survey, Gaines County. This well flowed 230 barrels of 32.1° gravity oil in 7 hours through $\frac{3}{4}$-inch choke on tubing, at total depth of 6,881 feet with oil string set at 5,660 feet. This pay zone may be a new one in the Clear Fork or may correspond with the Tubb pay zone. Confirmation awaits the release of samples.

NEW AREAS OF ESTABLISHED PAY ZONES IN PERMIAN

1. *Upper Delaware Mountain, Yates sand, and Seven Rivers.*—In Ward County along the Capitan reef trend, the Atlantic Refining Company's Wickett-University No. 1, in Sec. 12, Block 16, University Lands Survey, opened a new area called the Magnolia-Sealy south pool when it produced 452 barrels of 28.5° gravity oil with a gas-oil ratio of 427, at a depth of 2,911 feet plugged back from 2,920 feet after an 80-quart shot and a treatment with 9,000 gallons of acid. Production is coming from dolomite and sand from 2,888 to 2,905 feet, about 288 feet below the top of the Yates sand, possibly in the top of a Seven Rivers reef section. At the end of the year the pool had three oil wells, one gas well which was subsequently plugged, one dry hole, and three drilling wells.

The Sealy pool in Ward County, producing from the Yates sand, was extended one mile eastward by the completion of the Gulf Oil Corporation's O'Brien No. 127 and No. 129, in Secs. 35 and 36, respectively, Block F., G. & M.M.B. & A. Survey. The O'Brien No. 127 was completed with a potential of 254 barrels of oil, flowing through casing from sand and dolomite "pay" from 2,770 to 2,875 feet. The O'Brien No. 129 gauged 62 barrels of oil plus 30 per cent water, flowing on potential test with pay zone from 2,788 to 2,885 feet.

Kenneth Slack's Hayes No. 1, in Sec. 148, Block 34, H. & T.C. R.R. Survey, Ward County, was a 1940 discovery in the Delaware basin. The area has been named the Hayes field. On a potential gauge

the Hayes No. 1 flowed 21,262,000 cubic feet of gas per day with a spray of oil, through open 7-inch casing. The Delaware Mountain black limestone was topped at 5,003 feet and the Delaware Mountain sand at 5,044 feet with gas "pay" from 5,045 to 5,088 feet.

2. *Queen formation.*—A new area of shallow production in Pecos County, called the Walker area, was opened by R. L. Walker's White and Baker No. 1, in Sec. 86, Block 94, G.C. & S.F. Survey. This well, located on a subsurface prospect, was completed at a total depth of 2,016 feet flowing 19 barrels of 31.1° gravity oil through tubing after being shot with 40 quarts of nitroglycerine. The pay zone here is a sand from 1,985 to 2,016 feet in the Queen formation of the Whitehorse group. There were five producers in the area, and five rigs in operation at the end of the year.

Patillo's O'Neill No. 1, in Sec. 74, Block 10, H. & G.N. Survey, Pecos County, resulted in a new area of production between the Lehn and Masterson pools when it flowed 23 barrels of 34° gravity oil through ¼-inch choke on tubing after a 140-quart shot of nitroglycerine. Production is from sand from 1,605 to 1,660 feet in the Queen formation.

3. *Grayburg formation.*—During 1940 there were two new areas of production and two important extensions to producing fields in the Grayburg formation. One new area, the Olson field,[14] in southwestern Crockett County, was proved by the Moore Brothers' W. T. Noelke No. 1, in Sec. 10, Block G.G., G.C. & S.F. Survey, which was drilled to 2,371 feet, finding scattered porosity and saturation at 2,150 feet. On potential gauge, the well pumped 130 barrels of 27.4° gravity oil in 24 hours after treatment with 3,175 gallons of acid.

A second new area of Grayburg production, called the Live Oak field, also in Crockett County, was opened by the Moore Brothers' Hoover No. 1, in Sec. 16, Block 1, G.C. & S.F. Survey, when it pumped 52 barrels of 30° gravity oil after a 360-quart shot of nitroglycerine from 2,012 to 2,145 feet. Top of the Grayburg is at 1,950 feet, with porosity and staining from 2,040 to 2,120 feet, and total depth at 2,150 feet.

The McElroy field in Upton and Crane counties was extended southward 1½ miles by the Texas-Pacific Coal and Oil Company's Eddleman No. 1, in Sec. 208, Block F., C.C.S.D. & R.G.N.G. Survey, which pumped 233 barrels of oil after a 900-quart shot of nitroglycerine. The pay zone in this well from 2,945 to 3,175 feet is dolomite and sand of the Grayburg formation, the top of which was at 2,855 feet.

[14] The producing zone in the Olson field and the Live Oak field in Crockett County is considered by some geologists to be in the upper part of the San Andres formation. There is some evidence to substantiate this correlation, notwithstanding that it is placed in the Grayburg formation in this paper.

At present there are two producers and two drilling wells in the field.

The South Cowden field, in Ector County, was extended 1½ miles southwestward by the Forest Development Corporation's Paul Moss No. 1-H, in Sec. 48, Block 43, T. 2 S., T.& P. R.R. Survey. This well was completed, flowing 528 barrels of 34° gravity oil through tubing with gas-oil ratio of 896:1 after being shot with 1,600 quarts of nitroglycerine. Total depth of the well is 4,300 feet in the Grayburg formation with main oil "pay" from 4,210 to 4,285 feet. At the end of the year one well was drilling in the extension area. The older part of the field was enlarged by 1,240 additional acres during the last year.

An important Grayburg test was the Texas-Pacific Coal and Oil Company's Midland Farms No. 1, in Sec. 1, Block 40, T. & P. R.R. Survey, in southeastern Andrews County. This well is located in the Midland Basin area and was drilled with rotary tools to a total depth of 4,888 feet. The geological markers were as follows: top of Anhydrite 1,950 (+1,004); top of Yates sand 2,980 ? (−26); top of Grayburg 4,540 (−1,586). Samples from 4,860 to 4,870 feet in the Grayburg showed 10–20 per cent oil-stained dolomite. After 7-inch casing was set at 4,623 feet and after the well was plugged back to 4,860 feet, it showed only a small amount of oil and much sulphur water and was abandoned.

4. *San Andres formation.*—Oil-bearing strata occur in zones within the San Andres, ranging from the top to the base of the formation. Recent results of prospecting at each of these zones are considered separately as follows.

A. *Upper San Andres* (*Penn-Goldsmith*) *pay zone.*—The Penn-Goldsmith pay zone covers the uppermost 200 feet of the San Andres formation and includes both the top white crystalline dolomite facies and the subjacent brown granular dolomite facies. Wildcatting to the Penn-Goldsmith pay zone was carried out in Pecos, Crane, Ector, Andrews, and Crockett counties during 1940.

A new area of oil production was developed by the Forest Development Corporation's Bradley *et al.* No. 1 in Sec. 18, Block 43, T.3 S., T. & P. Survey, Ector County, which has been named the Douro area. The geological markers on this well were as follows: top of Anhydrite, 1,690 feet (+1,353); top of Yates sand, 2,870 feet (+171); top of Grayburg, 3,795 feet (−754); and top of San Andres, 4,320 feet (−1,189). The well was drilled to a total depth of 4,410 feet and subsequently plugged back to 4,362 feet to shut off bottom-hole sulphur water. The interval from 4,320 to 4,362 feet showed porosity and oil saturation and was treated with 10,000 gallons of acid. On potential test the Bradley *et al.* No. 1 pumped 102 barrels of 29.5° gravity oil in

24 hours. Two other wells have been drilled in the Douro area, each of which found insufficient porosity above the water level to make commercial producers and they were abandoned. The oil production in the Bradley *et al.* No. 1 is coming from the white crystalline facies of the upper part of the San Andres formation.

In northwestern Ector County, Grisham and Hunter reopened a small area of production from the upper San Andres with their R. B. Cowden No. 1 in Sec. 4, Block 34, T. 1 N, T. & P. Survey. This well, drilled as a proposed Tubb pay test, was carried to 6,090 feet and porous and oil-saturated dolomite recorded from 4,274 to 4,450 feet. After treatment with 10,000 gallons of acid, the R. B. Cowden No. 1 registered a potential of 283 barrels of 37.1° gravity oil, flowing with a gas-oil ratio of 880:1. An old well in the area, Grisham and Hunter's R. B. Cowden No. 1 in Sec. 10, ½ mile away, had originally been completed, producing 30 barrels of oil. Three more producers have been drilled in the area, and two wells are now drilling.

In southern Andrews County, an area of oil production and one of gas was developed in 1940 from the upper part of the San Andres. The area of oil production, known as the West Andrews pool, was opened in July, 1940, by Helmerich and Payne's University No. 1 in Sec. 11, Block 11, University Lands Survey. This well topped the San Andres at 4,260 feet and found scattered porosity and oil saturation from 4,270 to 4,475 feet, the total depth. The well was shot with 500 quarts of nitroglycerine, acidized with 19,000 gallons, and registered a potential of 168 barrels of oil plus 9 barrels of water in 24 hours pumping. Two other small pumpers have since been completed in the area.

Three miles southeast, a gas well, the Phillips Petroleum Company's Embar No. 1 in Sec. 102, W. L. Callahan Survey, was completed, producing 1,805,000 cubic feet of gas at a total depth of 4,336 feet after shooting and acidizing. The top of the San Andres was at 3,960 feet. Two shallow wells have been drilled in the area and abandoned, one to 2,500 feet and the other to 1,705 feet. At present two other wells are being carried deeper in search of Holt or Tubb pay production.

On the basis of oil showings in the top of the San Andres in the deep wells on the Todd Ranch structure in Crockett County, three shallow wells were drilled, resulting in two small producers and one dry hole. The area of shallow production on the Todd Ranch has been given the name Wyatt field. The discovery, the Stanolind Oil and Gas Company's J. S. Todd Unit No. 5, in Sec. 67, Block UV, G.C. & S.F. Survey, flowed 68 barrels of 21° gravity oil in 24 hours through ¼-inch choke. The gas-oil ratio was 12,700:1. This well topped the San An-

dres at 1,175 feet and is bottomed at a total depth of 1,225 feet. The second well pumped 34 barrels of oil per day from a total depth of 1,385 feet, with the top of the San Andres at 1,335 feet.

Production from the top of the San Andres was established in the Masterson pool, in Pecos County, by Davis' Fromme No. 1, in Sec. 110, Block 10, H. & G.N. Survey, which pumped 60 barrels of 25° gravity oil per day after being treated with 1,000 gallons of acid. The top of the San Andres is at 1,820 feet and total depth at 1,888 feet.

Hargrave's University No. 1 in Sec. 14, Block 18, University Lands, Pecos County, proved a ½-mile west extension to the Taylor-Link field when it pumped 253 barrels of oil from San Andres dolomite from 1,670 to 1,718 feet.

Another attempt in the Dunbar area of southwestern Gaines County was the Richmond *et al.* Brumley No. 1 in Sec. 17, Block A-12, Public School Land Survey. This well topped the San Andres at 4,360 feet and found slightly oil-stained dolomite from 4,415 to 4,470 feet. It was taken to 4,664 feet, treated with acid, and abandoned.

B. *The Seminole-Cedar Lake pay zone.*—The Seminole field, in Gaines County, was defined on the north end by the Humble's Auten No. 1 in Sec. 267, Block G., W.T. R.R. Survey. The field itself has enjoyed steady development throughout the year without any major extensions. The Cedar Lake field in northeastern Gaines County, which was opened during the latter part of 1939, now has nine producers. A wildcat 9 miles north of the field on the Gaines-Terry county line, the Tidewater's Buckner No. 1 in Sec. 3, Block C-37, Public School Land Survey, was non-porous in the regular Cedar Lake pay zone and went to 5,123 feet to find sulphur water in porosity from 4,957 to 5,005 feet. The Cedar Lake field was defined on the southeast flank by the Magnolia's Sandidge No. 1 in Sec. 110, Block M., E.L. and R.R. Survey, Dawson County, which was dry at 5,345 feet.

An important wildcat west of the Seminole field was Postelle's James No. 1 in Sec. 368, Block G., C.C.S.D. & R.G.N.G. Survey, which found the regular Seminole pay zone tight and was abandoned at 5,315 feet.

C. *Wasson-Bennett pay zone.*—The Waples-Platter area northeast of the Bennett portion of the Wasson field added one producer in the T. N. Sloan and Sloan and Zook's Waples-Platter No. 1 which extended production ¾ mile northeast, by flowing 161 barrels of oil from 5,285 feet. The feature was defined on the northwest by the Forest Development Corporation's Whisenant No. 1 in Sec. 553, which was dry at 5,515 feet. The Plymouth-Amerada's Brownfield No. 1 in Sec. 620, east of the Waples-Platter structure, was deepened below the regular pay to 6,270 feet, but failed to find further showings.

D. *Slaughter-Duggan pay zone.*—The Slaughter pool in Hockley County and the Duggan pool in Cochran County were connected by continuous development during 1940. The field now contains 54,820 proved productive acres. The Slaughter part of the field was extended southwest into Terry County by George Livermore's Jacobson No. 1 in Sec.6, Block D-11, C. & M. R.R. County Survey, which flowed 828 barrels of oil on potential gauge after being acidized in the regular Slaughter pay zone from 4,985 to 5,035 feet. Three rather important tests were drilled to the Slaughter-Duggan zone in 1940. The most northerly one was the Denver's Whiteface No. 1 in Labour 22, League 77, Reeves County School Land Survey. This test, originally projected to the Slaughter zone, found it tight from 4,470 to 4,570 feet and drilled to 4,794 feet, finding showings of oil and porosity from 4,750 to 4,794 feet. It failed to make a commercial producer and was abandoned. In southeast central Hockley County, the Cascade Petroleum Company drilled Walker No. 1 in Sec. 22, McCulloch County School Land Survey. It was drilled to 5,100 feet, found sulphur water in the Slaughter pay zone at 5,078 feet, and was abandoned. On the east side of the North basin, in northwestern Lynn County, the Wilcox's Powell No. 1 was drilled to 5,182 feet and found sulphur water in the Slaughter pay zone.

A new area of production was opened in north-central Mitchell County on the same structural trend as the Ira and Sharon Ridge pools in Scurry County and in the same pay zone as the Ira pool. This pool has not been given an official name, but is combined with the other two by the Railroad Commission of Texas as the Sharon Ridge field. N. V. Hilburn's Strain No. 1, in Sec. 82, Block 97, H. & T.C. Survey, was completed, pumping 86 barrels of 31° gravity oil at a depth of 1,801 feet after being shot with 520 quarts of nitroglycerine. The top of "pay" was at 1,647 feet, which is 257 feet below the top of the San Andres formation. At the end of the year, the field had four producing wells, one dry hole, and three in the progress of drilling. The stratigraphic section drilled in C. W. Hanes' C. I. Grable No. 1 is as follows.

	Depth in Feet	
Triassic	0– 275	
Permian		
Dewey Lake	275– 405	
Salado	405– 460	
Whitehorse	460–1,348	
San Andres	1,348–1,732	T. D.

5. *Holt pay zone-Clear Fork (?).*— The upper Clear Fork zone, which has produced in the Eastern platform of the Permian basin for many years and was found productive on the North Cowden struc-

ture during 1939, received several tests during 1940. These were the following.

Well	*Location*	*Holt Zone in Feet*	*Production*
Stanolind W. F. Cowden 1	Sec. 4, Blk. 43, T. & P. Ector County	5,143–5,237	Pumped 97 barrels oil plus 60 barrels water after acid
Barnsdall Blakeney 1-B	Sec. 2, Blk. A, P. S. L. Ector County	5,165–5,220	Sulphur water; dry and abandoned
York and Harper Foster 1-D	Sec. 8, Blk. 42, T. 2 S., T. & P. Ector County	5,512–5,569	Sulphur water; plugged back to regular Foster "pay"
Landreth and Shell J. L. Johnson	Sec. 43, Blk. 43, T. 1 S., T. & P. Ector County	5,160–5,308	Sulphur water; dry and abandoned
Gill Parker 1	Sec. 12, Blk. 45, T. 2 S., T. & P. Ector County	5,190–5,250	No showings
Grisham and Hunter R. B. Cowden 1	Sec. 4, Blk. 45, T. 1 N., T. & P. Ector County	5,380–5,410	Showings of dead oil
Gulf Wristen 5	Sec. 18, Blk. 5, H. & T. C. Ward County	3,970–4,100	900 feet oil on drill-stem test
Sinclair Wirt Davis 1	Sec. 32, Blk. 4, H. & T. C. Ward County	3,745–3,864	Sulphur water; dry and abandoned
Taubert *et al.* Crockett 1	Sec. 4½, Blk. 3, H. & T. C. Pecos County	3,150–3,300	Est. 2 million cubic feet of gas

6. *Clear Fork formation.*—A. The Sharon Ridge pool, in southwestern Scurry County, was extended 1½ miles northwest by the Ordovician's Burney No. 1 in Sec. 146, Block 97, H. & T.C., which pumped 246 barrels of oil after shot on potential gauge from the regular Clear Fork pay zone.

B. *Tubb pay zone.*—The Tubb pay zone on the Central Basin platform has not shown evidences of oil production except in central Crane County where the Tubb pool is located. This field was extended 2 miles northeast where some prolific wells from this zone have been drilled by the Gulf Oil Corporation during 1940. The largest of these was the Gulf's Waddell *et al.* No. 14 in Sec. 29, Block B-26, Public School Land Survey, which flowed 7,709 barrels of 36.5° gravity oil in 24 hours on potential gauge after treatment with 5,000 gallons of acid.

As mentioned previously, the A. G. Carter No. 5-D Wasson, located in Section 50, Block AX, P.S.L. Survey, Gaines County, in the Wasson field which flowed 230 barrels of 32.1° gravity oil in seven hours from same zone between 5,660 and 6,881 feet, may be producing from the equivalent of the Tubb zone in the Clear Fork.

DEVELOPMENTS IN PRE-PERMIAN OF WEST TEXAS

The year 1940 was one of the most active pre-Permian exploration years in the history of West Texas. Most of the wells were drilled in the southern part of the West Texas area, especially in Crane, Crockett, Pecos, and Ward counties.

Geophysical exploration was also concentrated mostly in the south part of the West Texas area. The most activity was in Crockett, Irion, Reagan, Schleicher, Sterling, and Tom Green counties.

NEW DISCOVERIES IN PRE-PERMIAN

Strawn production (lower Pennsylvanian).—The Todd[15] field of Crockett County produces from a crinoidal limestone of lower Pennsylvanian age, believed to be equivalent to part of the Millsap Lake group (lower Strawn). The discovery well, the Continental Oil Company and Stanolind Oil and Gas Company *et al.* J. S. Todd Unit No. 2 was completed in March, 1940, at a depth of 5,691 feet, producing 840 barrels in 12½ hours through 11/16-inch choke on 2-inch tubing with gas flow at a rate of 1,150,000 feet per day. The crinoidal limestone appears to be a reef deposit which is thickest on the top of the structure and which thins and disappears toward the east. There is some possibility of a strike fault on the west side of the present structure between the Amerada Petroleum Corporation's J. S. Todd No. 1 and the Continental *et al.* J. S. Todd No. 7 where there is 280 feet difference in elevation of the top of the limestone in a distance of 1,320 feet. The possible fault would be pre-Permian in age. The crinoidal "pay" was discovered while searching for production from the Ellenburger (Lower Ordovician) and the chances for production from that formation seem good since the highest part of the structure is about 300 feet higher than that in any Ellenburger well drilled to date. On December 31, 1940, there are seven producing wells in the field. It has been limited on the east and southeast by dry holes and locally probably on the west by steep dip and possible faulting. However, there is a large prospective area on the north and northwest and a strong possibility of several isolated anticlines being developed on the large structural uplift.

Silurian production. Shipley deep pool, Ward County.—The first production in Texas from the Silurian[16] was discovered in the Gulf Oil Corporation's Wristen Brothers No. 5 in Sec. 18, Block 5, H. & T.C. Survey, Ward County. The well was completed, December 12, 1940, at a depth of 7,075 feet plugged back from 9,187 feet. On test it flowed at a rate of 3,049 barrels per day of 32.2° gravity oil through casing and tubing with a gas-oil ratio of 1,148 : 1 after treating with 10,000 gallons of acid. The oil is vaseline-like and does not flow under ordinary atmospheric temperature and conditions. The well had very

[15] D. D. Christner, *op. cit.*

[16] C. D. Cordry and M. E. Upson, "Silurian Production, Shipley Field, Ward County, Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 25, No. 3 (March, 1941), pp. 425–27.

promising showings of oil from the Ellenburger which were never thoroughly tested due to mechanical difficulties. This section has been identified as Silurian[17] from equivalent rocks found in several other wells.

The producing formation is white crystalline limestone which is pink in places and contains many crinoid stems. It is very glauconitic in the upper part, and contains a large quantity of chert. No fossils have been found in this formation. It lies above known Ordovician and below rocks which have been identified as Devonian by paleontologists.[18] However, there are some geologists in the area who do not agree with this correlation.

The section penetrated in the well as interpreted by the writers is as follows.

	Depth in Feet
Surface and lower Dockum group (Triassic)	0– 325
Permian	
Ochoa series	325–1,675
Guadalupe series	1,675–2,900 (?)
Leonard and Wolfcamp series (undifferentiated) (?)	2,900–6,315
Devonian	6,315–6,930
Silurian	6,930–7,235
Ordovician	
Montoya	7,235–7,400
Simpson	7,400–9,002
Ellenburger	9,002–9,187

There is some disagreement among local geologists on the question of whether or not there is any Montoya present. Those who believe there is none would put this section in the Simpson formation.

The end of the year there was one producer and one drilling well in the pool.

Simpson production (Middle Ordovician). Abell field, Pecos County.—The second occurrence in West Texas of oil production from sand in the Simpson formation (Middle Ordovician) was discovered by the Taubert-McKee and Siemoneit's V. W. Crockett well No. 1 in Sec. 4½, Block 3, H. & T.C. Survey, Pecos County. This well was completed, November 9, 1940, at a depth of 5,357 feet, with a natural flow of 933 barrels of 43° gravity oil in 11½ hours through ½-inch choke on 2-inch tubing with a gas-oil ratio of 783:1.

The producing sand is believed to be approximately 10 feet thick.

This well is located one mile south of the Magnolia Petroleum Company's S. McKee No. 1-A A. which headed oil from the same horizon. The two wells are of about equal elevation structurally.

The stratigraphic section penetrated in the Crockett well is as follows.

[17] E. H. Powers, *op. cit.*, p. 126.

[18] *Ibid.*

	Depth in Feet
Surface and Dockum group (Triassic)	0– 240
Permian	
Ochoa series	240–1,090
Guadalupe series	1,090–2,360
Leonard and Wolfcamp series (undifferentiated)	2,360–4,780
Simpson (Middle Ordovician)	4,780–5,357

There is some disagreement as to whether there is any Montoya in this area. Elliott Powers[19] recognizes possible Montoya in the Magnolia's McKee test 1-A. The equivalent rocks in this well are found from 4,755 to 4,910 feet. Some local geologists correlate the section with the Oklahoma Simpson section. According to this correlation the rocks from 4,780 to 4,965 feet would be Bromide, the rocks from 4,965 to 5,357 would be Tulip Creek. The "pay" would be in the lower Tulip Creek. An additional sand "pay" has been found about 445 feet below this "pay" in other wells which would be correlated as near the base of the McLish. A majority of the geologists of the area prefer to call all of the section from 4,780 to 5,357 feet Simpson.

There was one producer and four drilling wells at the end of the year.

Ellenburger production (Cambro-Ordovician). New Sand Hills pool, Crane County.—A new Ordovician pool was discovered in the Sand Hills field by the Gulf Oil Corporation *et al.* J. B. Tubb well No. 1-A in Sec. 20, Block B-27, P.S.L. Survey. The well was completed, April 28, 1940, flowing at a rate of 5,130 barrels of 38.1° gravity oil through casing and tubing plus $5\frac{1}{2}$ per cent water at a depth of 5,783 feet with a gas-oil ratio of 402:1.

This discovery is about $2\frac{1}{2}$ miles southeast of the original Sand Hills Ordovician pool and is probably separated from it by at least one strike fault. This well produces from the Ellenburger formation of Lower Ordovician age from the top of which the upper 175 feet has been eroded, while in the original pool, production is from near the top of non-truncated Ellenburger, and the Simpson formation (Middle Ordovician) also is productive. Porosity in the Ellenburger in this pool for the most part is due to fractures in the dolomite.

The stratigraphic section drilled in this well is as follows.

	Depth in Feet
Guadalupe series (Permian)	1,325–2,640
Leonard series	2,640–5,760
Ellenburger (Lower Ordovician)	5,760–5,783

At the end of the year there were five producers in the pool with no dry holes.

[19] E. H. Powers, *op. cit.*, p. 125.

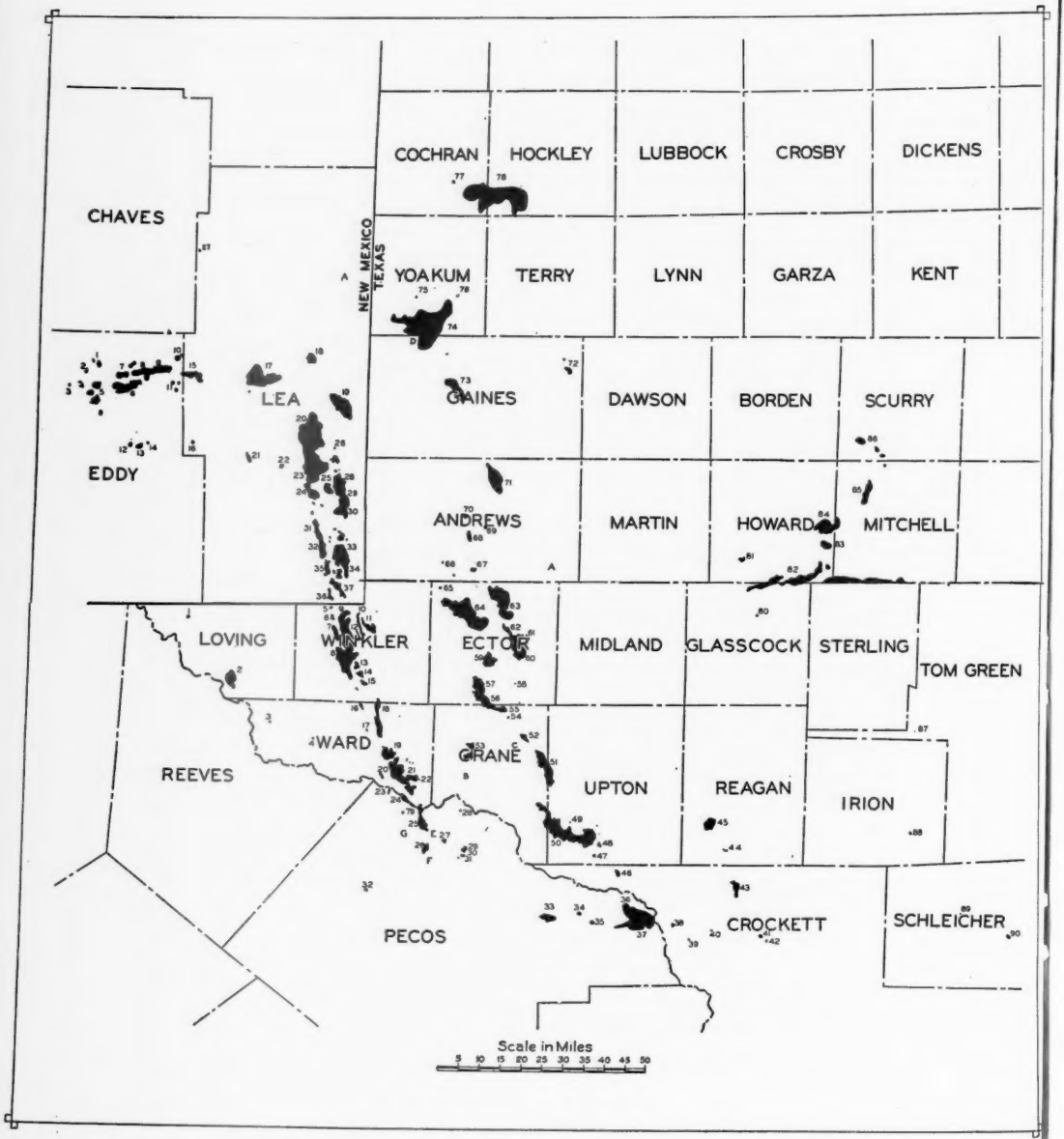


FIG. 1.—Base map of West Texas and southeastern New Mexico, showing location of fields and more important wildcats.

WEST TEXAS FIELDS

1. Mason
2. Wheat
3. Monroe
4. Quito*
5. Eaves
6. Leck
7. Henderson
8. Hendricks
9. Scarborough
10. Keystone (Colby sand)
11. Keystone lime
12. Kermit
13. Emperor deep
14. Emperor
15. Halley
16. Magnolia Sealy
17. Magnolia Sealy South*
18. North Ward
19. Estes
20. South Ward
21. Shipley
22. Shipley deep*
23. Netterville
24. Payton
25. Pecos Valley High Gravity
26. Pecos Valley Low Gravity
27. Lehn
28. Abell*
29. Masterson
30. Apco
31. Fromme*
32. Prior
33. Taylor-Link
34. Walker*
35. White-Baker
36. Toborg
37. Yates
38. Noelke*
39. Olson*
40. Live Oak*
41. Todd Deep*
42. Wyatt*
43. World
44. Grayson
45. Big Lake
46. Crockett
47. Webb-Ray
48. Hurdle
49. Herrington
50. McCamey
51. McElroy
52. Dunes
53. Sand Hills
54. Ella Waddell
55. Waddell
56. Jordan
57. Penwell
58. Douro.*
59. Harper
60. South Cowden
61. Foster
62. Johnson
63. North Cowden
64. Goldsmith
65. North Goldsmith
66. West Andrews*
67. Emma
68. Fuhrman
69. Parker
70. Deep Rock
71. Means
72. Cedar Lake
73. Seminole
74. Wasson
75. West
76. Waples Platter
77. Dean
78. Slaughter
79. Grassroots*
80. Carter
81. Moore
82. Howard-Glasscock
83. Snyder
84. Iatan-East Howard
85. Mitchell
86. Sharon Ridge
87. Funk*
88. Irion
89. Opp
90. Page

NEW MEXICO FIELDS

1. High Lonesome
2. Red Lake
3. Dayton*
4. McMillan
5. Artesia
6. Loco Hills
7. Leonard
8. Grayburg
9. Jackson
10. Robinson
11. Shugart
12. Getty
13. Barber
14. PCA
15. Maljamar
16. Halfway
17. Vacuum
18. South Lovington
19. Hobbs
20. Monument
21. Lynch
22. West Eunice
23. Eunice
24. South Eunice
25. Arrowhead
26. Skaggs
27. Caprock*
28. Hardy
29. Penrose
30. Skelly
31. Lynn
32. Cooper
33. Mattix
34. Langlie
35. Jal
36. Eaves
37. Rhodes

IMPORTANT WELLS

WEST TEXAS

A. Texas and Pacific Coal and Oil Company's Midland Farms No. 1
B. Gulf Oil Corporation's Waddell *et al.*,No. 17
C. Gulf Oil Corporation's University, No. 1-F
D. Amon G. Carter *et al.*, Wasson, No. 5-D
E. Humble Oil and Refining Company's Bertha Young, No. 1
F. Culbertson and Irwin Inc.'s Mary Heiner, No. 1
G. Plymouth Oil Company's Richard Levy, No. 1

NEW MEXICO

A. Ventura's Lowe, No. 1

* 1940 discovery.

PRE-PERMIAN WILDCATS

DRY HOLES AND EXTENSIONS

More deep wildcat test wells were drilled in Pecos County than any other county during 1940. The Humble Oil and Refining Com-

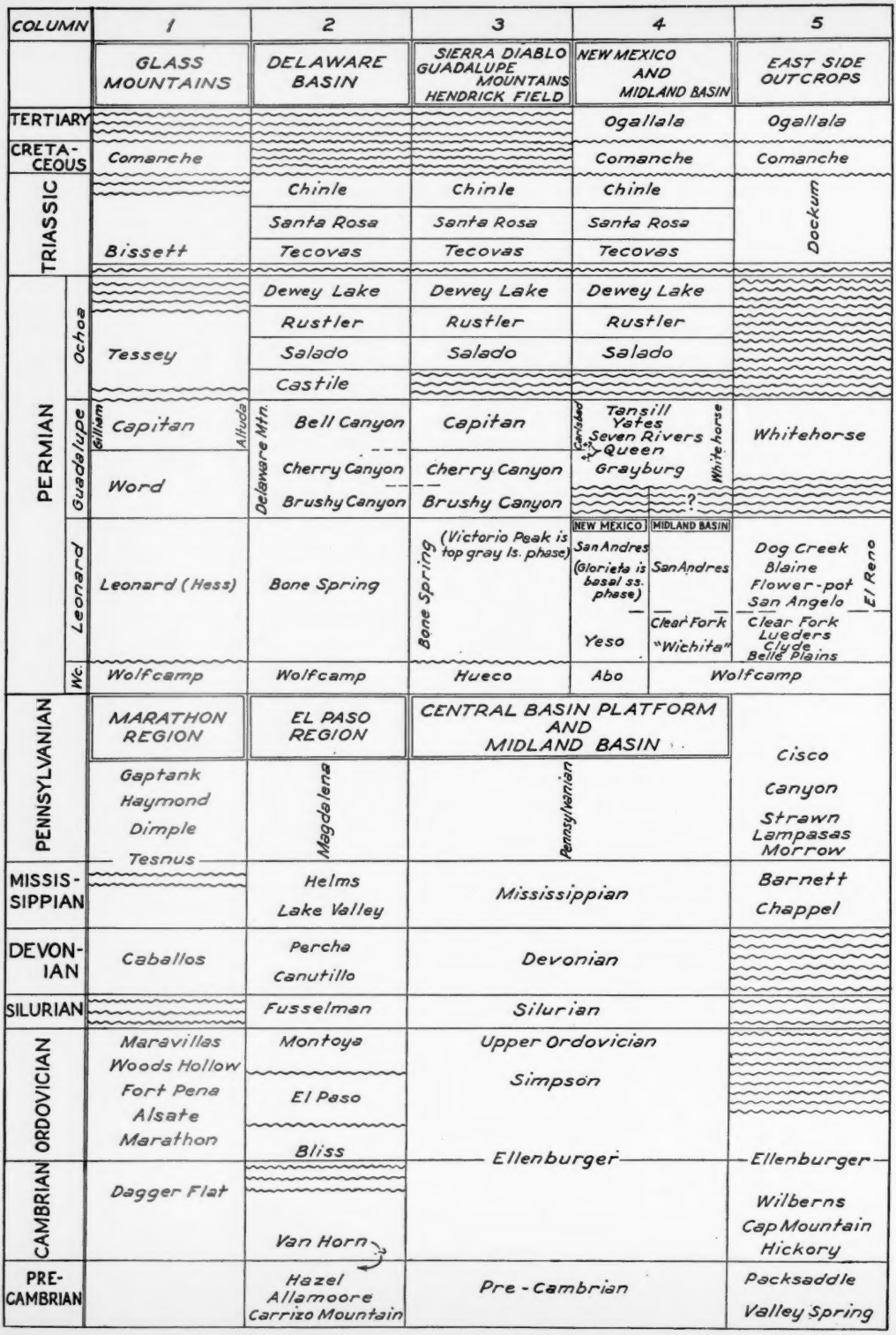


FIG. 2.—Schematic correlation chart of West Texas formations.

pany's Shearer No. 1, in Sec. 99, Block 10, H. & G.N. Survey, is an extension northwest of the Apco field. It is a small producer at a depth of 4,697 feet plugged back from 4,782 feet. The detrital zone at the base of the Permian was topped at 4,670 feet, datum −2,233, and the Ellenburger formation (Lower Ordovician) was topped at 4,696 feet. More than half the Ellenburger is removed by pre-Permian erosion. The "pay" in the Ellenburger in this well is higher in the section, however, than that of the previous producers of the Apco field.

The Humble Oil and Refining Company's Bertha D. Young No. 1, in Sec. 73, Block 10, H. & G.N. Survey, drilled the thickest basal Permian conglomerate found to date in West Texas. The conglomerate was topped at 5,186 feet and was 438 feet thick in this well. With an elevation of 2,455 feet, the Simpson was topped at 5,624 feet and the well was abandoned at a depth of 7,430 feet still in the Simpson. The top of the Simpson in this well corresponds very closely with the top of the Simpson found in the Abell field 10 miles northeast. Pre-Permian faulting might be suggested north of this well, since the Magnolia's Abell-Eaton well No. 2 two miles north had only a few feet of basal Permian conglomerate before entering truncated Ellenburger with about 425 feet removed from the top. This shows at least 2,700 feet of dip in 2 miles.

The Plymouth Oil Company's Richard Levy No. 1, in Sec. 104, Block 8, H. & G.N. Survey, Pecos County, was abandoned at a depth of 6,473 feet in Devonian chert and limestone. The elevation is 2,473 feet and the Devonian was topped at 6,095 feet. This section seemed to correspond with the Devonian section of the Gulf's Wristen Brothers No. 5. The well was abandoned before reaching the Silurian because of the extremely hard drilling in the cherty limestone section.

Early in the year the Olson Drilling Company and Bryce McCandless' V. W. Crockett well No. 1 in Sec. 5, Block 110, T.C. R.R. Survey, Pecos County, was completed with a gauge of 996 barrels of 42° gravity oil in 10 hours and 45 minutes with a gas-oil ratio of 5,184:1. This well is 1½ miles southwest of the Apco field. It produces from the same part of the Ellenburger as the Apco field. At the present time it is not known whether or not this is a new field or an extension to the Apco field.

A new Ellenburger discovery which is in the stage of completion is the Culbertson and Irwin, Inc. Mary Heiner No. 1 in Sec. 589, G.C. & S.F. Survey. The total depth is 5,665 feet plugged back to 5,509 feet. The well has an elevation of 2,549 feet, topped the detrital zone at 5,110 feet, and the Ellenburger at 5,128 feet. Approximately 100 feet of Ellenburger is missing in this well from the top.

DEVELOPMENTS IN SOUTHEASTERN NEW MEXICO

There were 542 wells drilled in southeastern New Mexico during 1940, of which 452 were oil wells, 16 gas wells, and 74 were dry holes. The percentage of dry holes (13.5 per cent) drilled this year exceeds that of last year not because a greater number of exploratory tests were drilled, but because development and extension drilling proved more hazardous in the lenticular, irregularly cemented "sands" flanking the Artesia-Maljamar nose on the south and north.

No tests exploring horizons deeper than those already drilled in past years were completed during the year. In view of the production being obtained in contiguous areas of Texas in formations older than the Permian, this lack of deep testing in southeastern New Mexico is noteworthy.

DISCOVERIES

Only two new pools were discovered in New Mexico during 1940.

The Dayton pool in T. 18 S., R. 26 E., Eddy County, on the west side of the Pecos River, was discovered by M. Yates, Jr., in July. McCall No. 1, in Section 24, completed at a total depth of 1,032 feet in sand probably Grayburg in age, flowed an estimated 100 barrels per day of 36° gravity oil. The "pay" is equivalent to that in the Loco Hills area 15 miles east.

At the close of the year, this pool had five producers and five drilling wells. The wells are completed at a reported average of about 100 barrels per day and it is found necessary to shut off artesian water flow 150–200 feet above the "pay" prior to shooting. Thus far, the total production has been negligible and the pool is not expected to add appreciable reserves.

The Caprock pool was discovered in the last quarter of the year through the drilling of the Great Western's State 1-D in Sec. 30, T. 12 S., R. 32 E. This well was drilled to a total depth of 4,385 feet where it obtained water in the San Andres limestone and was then plugged back and perforated opposite a showing in sand at 3,050 feet. It was completed with a reported pumping rate of 16 barrels of oil and 9 barrels of water per day. Lacking pipe-line connections, no oil has been marketed. Production is from the "Red sand" of the upper Queen, which was early used as a correlation marker in the old Artesia field and vicinity. This sand rarely produces in the district, though producing sands in the High Lonesome and Shugart areas are thought to be in the same general zone. Though the oil production from this well or this "pay" may be relatively unimportant, the possibility of production on a larger scale from flanking sands or from stratigraphically

lower limestones higher on structure increases the future importance of this Caprock area.

The principal development took place in the Loco Hills pool of Eddy County where 83 wells were drilled, 64 of which were oil wells, and in the Maljamar pool of Lea County with 58 completions, all producers.

The intensive campaign begun in 1939 in the Vacuum pool was completed this year and 66 producers were drilled, with one dry hole helping to outline the pool. Only a small amount of additional drilling will be required to complete the development.

The Arrowhead pool was the only area in southern Lea County very active during the year. Forty-one producers were completed with exceedingly high average initial production. The old limestone-ridge fields and the sand-belt fields east of them received only a moderate amount of drilling, most of which was of the development type.

EXPLORATORY TESTS

Important exploratory wells drilled include the Ventura's Lowe No. 1 in Sec. 26, T. 13 S., R. 37 E. This well was drilled to a total depth of 6,300 feet and, though structurally high, failed to obtain effective porosity and did not show oil, gas, or water. The San Andres was encountered at 4,610 and 300 feet of Yeso was drilled before abandonment. The location was influenced by seismograph work, and the lack of porosity on a favorable structure may have a discouraging effect on future exploratory efforts in this part of Lea County.

Southwest of Carlsbad in Eddy County, two additional wells were drilled during the year in the attempt to develop production from the possible stratigraphic trap formed by the "liming up" of the Delaware sands approaching the Capitan reef. Paul Moran's Ramux No. 1, in Sec. 18, T. 23 S., R. 26 E., and the Turner and DeVito's Devito No. 1, in Sec. 12, T. 23 S., R. 25 E., about one mile west, continued the east-west line of exploratory tests begun last year by the Roundey-Roundey in Sec. 8, T. 23 S., R. 26 E. The effort, thus far not successful in yielding production, has given much interesting information on the changes occurring in the Delaware sands as they approach the reef front.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1064-1080, 1 FIG.

NEW DEVELOPMENTS IN NORTH AND WEST-CENTRAL TEXAS, 1940[1]

NORTH TEXAS GEOLOGICAL SOCIETY[2]
Wichita Falls, Texas

ABSTRACT

During the year 1940, the north and west-central Texas districts developed important new production in the following stratigraphic formations.

Ellenburger limestone (Cambro-Ordovician) in the western part of the K.M.A. field in Wichita County.

Chappel limestone (Mississippian) in two pools on the Bend arch in Young County and in one pool on the eastern edge of the Permian basin in Stonewall County.

Bend conglomerate in one pool in Clay County, and in one pool in Montague County, both in the Forth Worth syncline.

Caddo limestone (Bend) in two pools on the Bend arch in Archer County, and in three pools in the Fort Worth syncline, two of them in Clay County and one in Montague County.

Strawn series (Pennsylvanian) in two pools on the Bend arch in Archer County, and in one pool on the east flank of the Bend arch in Clay County.

Canyon series (Pennsylvanian) in two pools on the west flank of the Bend arch in Baylor County, in one pool in Jones County, in one pool on the Electra arch in Foard County, and in one pool in Wilbarger County in the Red River syncline.

Cisco series (Pennsylvanian) in practically every producing county in the area, the most significant of which was probably in the Fargo pool in the Red River syncline in Wilbarger County.

Probably the only new stratigraphic discovery in the area was the tentative identification of Viola limestone (Ordovician) in two of the deeper wells in Clay County and in two in Montague County, and in one in Wise County, all in the Fort Worth syncline.

Total production for north and west-central Texas for 1940 was 49,221,930 barrels.

INTRODUCTION

The north and west-central Texas districts include the area from the Llano uplift in central Texas, northward to the Red River and from the eastern rim of the Midland basin on the west side to include the Fort Worth syncline on the east side.

The major structural features of the area are the Bend arch extending due northward from the Llano uplift into Wichita County flanked on the east by the Fort Worth syncline, which, commencing at approximately the center of the west line of Clay County, extends in depth southeastward through Clay County, across southern Montague County, through northeastern Wise County and across central Den-

[1] Read before the Association at Houston, April 4, 1941. Manuscript received, March 19, 1941.

[2] This paper was prepared by a committee consisting of H. F. Smiley, L. E. Patterson, and J. M. Clark from papers presented before the North Texas Geological Society by W. C. Bean, Shell Oil Company, Inc.; J. M. Clark, Tide Water Associated Oil Company; Henry Craig, Olney, Texas; H. C. Fountain, Magnolia Petroleum Company; J. F. Gibbs, Panhandle Refining Company; L. L. Hardin, Sinclair Prairie Oil Company; D. D. Heninger, Ohio Oil Company; A. C. Hornady, Phillips Petroleum Company; P. M. Martin, Continental Oil Company; L. E. Patterson, Cities Service Oil Company; Tom F. Petty and Robert Roth, Humble Oil and Refining Company; Roy Seitz and E. M. Stilley.

ton County. The Electra arch extends from northern Clay County westward across north Wichita County and central Wilbarger and Foard counties. The Muenster arch extends through the southeast corner of Cooke County diagonally across that county to the northwest and through northeastern Montague County. The Red River syncline parallels the Electra arch on the north and increases in depth westward as it enters Wilbarger County and continues to deepen westward through northern Hardeman County.

New developments for the year consisted mainly of the discovery of new productive pools in formations of Pennsylvanian age already productive elsewhere in the district. The finding of commercial production in the Ellenburger limestone in the western part of the K.M.A. field in Wichita County is probably the district's most important discovery in the Ellenburger. New, also, is the discovery of productive sands in the lower marine Cisco and also in the Canyon series in the Red River syncline in northern Wilbarger County.

The presence of Simpson sediments was further demonstrated by deep tests in the Fort Worth syncline. No sands of any importance were found and the sections drilled were predominantly limestone with some green shale. The greatest thickness of Simpson was found in the Ramsey Petroleum Corporation's Loring No. 1 drilled on the south flank of the Rogers pool in north-central Montague County, where 420 feet of Simpson limestone and green shale were present. The Simpson in the syncline is at the present time generally believed to be the lower part of the group.

The first Viola to be recognized in the syncline was in the Loring test.

ARCHER COUNTY

Thirteen wildcats were drilled to depths below 4,300 feet in this county during the year. Of this number, 8 were Pennsylvanian tests, of which 4 stopped in the Strawn series,[3] 2 tested the Chappel formation of Mississippian age, and 3 penetrated the Ordovician, stopping in the upper part of the Ellenburger group. These operations resulted in the discovery of two new pools and one important extension.

Although no important stratigraphic horizons formerly unknown in this area were discovered, these several tests have served collectively to indicate the areal distribution and development of the older Pennsylvanian and pre-Pennsylvanian reservoir and potential-reservoir rocks. Pre-Pennsylvanian tests drilled during 1940 and in earlier years show that the Chappel limestone is present in most of Archer County.

[3] M. G. Cheney, "Geology of North-Central Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 1 (January, 1940), pp. 65–118.

Though showings of oil have been encountered in the Chappel, it is not yet productive in the county. The deep tests have likewise proved the presence of the Smithwick group in most of the county. Limestones in this group are now producing in the Coleman pool in central-northeast Archer County, in the Hull-Silk pool in north-central Archer County, and in the Mankins pool west of the Hull-Silk pool. This group may therefore be considered as an important source of oil in future prospecting in this county.

The more important discoveries during 1940 were the Vogtsberger pool in northeast Archer County and the Coleman pool in central-northeast Archer County.

The discovery well in the Vogtsberger pool was Gant and Medders *et al.* August Vogtsberger No. 1, Sec. 3, German Emigration Land Co. Survey A-146. This well was completed in August, 1940, in a sand and interbedded sandy shale section at 4,659–4,755 feet. The total depth was 5,335 feet. Initial production, after the well was shot, was 80½ barrels of 41.6° gravity oil in 2 hours through ½-inch choke.

Discovery well in the Coleman pool was the Shell Oil Company's Coleman No. 1, Sec. 74, ATNCL Survey. The well was completed in October, 1940, from limestone at 5,009–5,058 feet, belonging to the Smithwick group, producing 255 barrels of 42° gravity oil in 3 hours through 2-inch tubing, after acidizing. The total depth was 5,468 feet.

In December, 1940, Kadane's Griffin "A" No. 1, Block 13, Palo Pinto County School Land, Survey A-339, in the northwestern corner of the county, was completed, producing 344 barrels in 8 hours through ½-inch choke from a sand at 4,337–4,351 feet, total depth. This well extended the Griffin pool one mile east.

In July, 1940, first production from limestone in the Smithwick group in the Hull-Silk pool was discovered by Chapman-McFarlin's Wilson No. 7-E in the E. Hall Survey A-682. This well, total depth, 5,091 feet, was completed, producing 42 barrels of 41° gravity oil in one hour through 2-inch tubing after acidizing, and is producing from limestone at 4,612–4,632 feet.

WICHITA COUNTY

New production was found during the year in both shallow and deep formations. A shallow discovery was Akin, Dimock, and Costley's Oates No. 1, about 5 miles southeast of Burkburnett, which had an initial production of 30 barrels from a Cisco sand from 1,313 to 1,328 feet. A deep discovery, representing a new producing zone for the county was in the Fain-McGaha Oil Corporation's Griffin "B" "Ellenburger" No. 1, in the southwest part of the K.M.A. field. This well

flowed 179 barrels in 3 hours from saturated Ellenburger dolomite at a depth of 4,352–4,386 feet, total depth. The top of the Ellenburger was at 4,315 feet. During the year, two other wells developed production from near the top of the Ellenburger in Archer County, a few miles southeast. The importance and extent of this new zone are yet to be determined.

The only extensions of importance in 1940 were of the K.M.A. field. Dorian and Barnes' E. M. Barnes "B" No. 1 extended the field one mile north of the farthest west producer. G. W. Cooper's Waggoner No. 33 extended the field about a mile northwest, and the Hanlon-Buchanan Inc. *et al.* T. L. Burnett No. 1 extended it ½ mile northeast.

Three wells reaching the Ellenburger provided new information. Omohundro's Kempner No. 1, 3 miles southwest of Wichita Falls, encountered the Ellenburger at 5,615 feet; Chambers and Simmons' Chenault No. 1, 1½ miles north of Burkburnett, found the Ellenburger at 3,230 feet. Geologically, the most important well to reach the Ellenburger was Bowen's McKinley No. 1, about 2 miles north of Wichita Falls. This well encountered the Ellenburger at 6,003 feet, after having drilled post-Ellenburger Ordovician, probably Simpson, from a little below 5,700 feet. Pennsylvanian beds overlie the Ordovician in this well.

WILBARGER COUNTY

Only one new field was discovered during the year, by the completion of the Amerada Petroleum Company's Goodpasture No. 1, 660 feet north and 660 feet east of the southwest corner of Sec. 35, Block 15, H. & T.C. Ry. Co. Survey, in the northern part of the county. The well was drilled to a total depth of 6,717 feet and was plugged back and completed in a sand at 3,230–3,252 feet, with an initial production of 241 barrels of 41.5° gravity, green, paraffine-base oil, in 16 hours.

During the drilling of this well, four separate productive formations were established for the area, now known as the Fargo field.

	Depth in Feet	
1. Cisco sand	3,232–3,252	Well was completed at this depth
2. Canyon sand	3,963–3,976	Recovered 3,225 feet of 40° gravity oil and 275 feet of fresh water in 45-minute drill-stem test
3. Strawn limestone	4,407–4,422	Recovered 450 feet of 35° gravity oil and 275 feet of fresh water in 1-hour drill-stem test
4. Ellenburger limestone	6,311–6,330	Swabbed and flowed 15 barrels of 42° gravity oil per hour

Each of these formations except the Ellenburger limestone is now producing from subsequent tests.

Beds which crop out on the surface in the Fargo area belong in the uppermost part of Clear Fork Permian, immediately below the outcrop of the San Angelo sandstone. The surface is covered with a mantle of wind-blown sand of recent age, obscuring all mappable beds. However, it has long been known that a regional fold traverses the area from east to west, as subsurface structure was mapped on the "base of the redbeds" as long as at least 15 years ago from information furnished by widely scattered dry holes, supplemented in some cases by core drilling. The location for the discovery well was selected, however, as the result of reflection-seismograph work, which showed a closed anticline previously untested except by shallow wells.

Information furnished by the discovery well may be summarized by the following identification of the section encountered in the well.

Formation	*Depth in Feet*	
Clear Fork	0–1,190	
Normal Wichita Albany	–2,050	
Pontotoc	–3,095	Includes approximately 300 feet of lower Wichita Albany and some Cisco
Marine Cisco	–3,420	
Canyon	–4,320	
Strawn	–6,160	
Simpson	–6,288	
Ellenburger	–6,717	Total depth in Ellenburger

The identification of the producing limestone at 4,407–4,422 feet as being Strawn in age is made on the basis of paleontology. It is very possible, however, that it should properly be placed in lower Canyon, as the approximate stratigraphic equivalent of Palo Pinto limestone.

JACK COUNTY

One new pool was opened in Jack County during 1940. This was the Mathis pool, about 6 miles southwest of Jacksboro, and 3 miles southeast of the eastern edge of the east Bryson pool. By the end of 1940, eight producers and one dry hole had been drilled in the pool. This pool produces from a Strawn sand in the same general zone as that producing in the Bryson pool, the sand being about 15 feet thick and encountered near 2,900 feet in depth.

The existing producing areas were further developed, the east Bryson field experiencing the greatest development. This development was in a northeast direction, the limits of which are not fully determined to date.

The Continental Oil Company's Robertson No. 1, 6 miles southwest of Jacksboro and 2 miles south of Mathis pool, encountered a sand which made 12 barrels of oil, and 2½ million cubic feet of gas daily from 4,651 to 4,662 feet, in the Bend section. A Mississippian

limestone with good oil staining was drilled from 5,307 to 5,360 feet and a dolomite conglomerate with a stain and an odor of oil was drilled from 5,360 to 5,380 feet, the top of the Ellenburger. The well made 70 barrels in 12 hours after acidization of the section at 5,350–5,386 feet. Production declined rapidly and the well is being worked on at this time. The total depth was listed as 5,577 feet in Ellenburger limestone. This well indicates that this entire area possesses opportunities for production in the Bend and Mississippian sections. This was the first well in Jack County to obtain production in Mississippian limestone.

The Rathke Oil Company's Moseley No. 1, 11 miles southeast of Jacksboro, a cable-tool test, found sand showing oil at 3,690–3,760 and 3,725–3,790 feet, both being in the Strawn. It reportedly encountered the top of the Smithwick limestone at 4,265 feet, and had a total depth of 5,347 feet. Showings of oil and gas were found from 4,498 to 4,552 and from 4,745 to 4,762 feet in the Bend section. This well will probably be completed as a gas well.

YOUNG COUNTY

The drilling of both shallow and deep wells continued in Young County in 1940; however, no deeper formations were penetrated than had heretofore been reached, and no new stratigraphic horizons were discovered. Some extensions to old pools were made in south Young in the Strawn and Bend series and about 200 tests were made in north Young in search for the shallow oil of the Cisco series.

Among the deeper tests, the most significant discovery of the year was Strong and Tidwell's Stovall No. 1, 3 miles southwest of Newcastle. In April, this well began flowing by heads when the Chappel limestone of lower Mississippian age was penetrated from 4,584 to 4,634 feet. Drilling continued in this limestone and into the Ellenburger where flowing sulphur water was obtained. The well was then plugged back, to shut off water, and the Mississippian limestone was acidized. After flowing sulphur water for 10 days, the well began to make 150 barrels of 42° gravity oil with the water. The daily allowable was set at 144 barrels and the well has consistently flowed this amount during the year 1940.

Another discovery in the Chappel limestone was made by T. D. Humphrey on the Jeffrey land in TE&L Survey 468, five miles north of Graham, to open the Dalrymple pool. This well had initial production of 40 barrels with some sulphur water.

Kerlyn and Phillips in TE&L Survey 1951, two miles southeast of Loving, extended Strawn production 2 miles north of the Manning district.

The most valuable discovery of the year was Keith's Rogers No. 1, three miles south of Olney in TE&L Survey 219, which opened the Rogers shallow pool. This well was finished in oil sand from 897 to 908 feet, producing 100 barrels a day. At present, there are 23 wells in the pool which are pumping and flowing. The average sand thickness is about 15 feet, although some wells have as much as 40 feet of sand and are capable of flowing more than 500 barrels per day.

This production is on the north flank of a structure with about 10 feet of closure. The sand, of dune type, is absent on the top of the structure, due to non-deposition.

Another pool of probable lesser significance was the L. T. Burns on the Larrimore land in TE&L Survey 210. To date, there are four wells producing about 20 barrels each from a sand 35 feet below the Gunsight limestone. This pool is in a stratigraphic trap associated with some northeast nosing.

STEPHENS COUNTY

A new Mississippian limestone producing area was discovered by Horwitz and Oldham's Maury No. 4, in the Dance pool in the northwestern part of the county. This well drilled into the Ellenburger and casing was set, after which the Mississippian limestone was perforated with 20 shots from 4,446 to 4,460 feet and 20 shots from 4,512 to 4,528 feet. The well was then treated with 5,000 gallons of acid and completed in August, with an initial production of 124½ barrels in 5 hours through a 7/32-inch tubing choke. It is now reported that at the end of the year the well was making its allowable of 60 barrels, having been put on the pump in the meantime.

CLAY COUNTY

Many tests were drilled in various parts of the county during the year and have furnished stratigraphic and structural information as well as resulting in the discovery of three new fields, the most important of which is the Shell's Henderson field.

One of the interesting facts developed during the year was the relatively high position of Cambrian and pre-Cambrian rocks underlying the Petrolia field in northern Clay County. Two wells, less than ½ mile apart, were drilled to the basement complex during 1940. In the higher of these, the British American's Stine No. 1, Block 2, Parker County School Land, the top of the Cambrian strata is tentatively placed at 2,062 feet (minus 1,068) feet, and granite was reached at 2,325 feet, or 1,331 feet below sea-level. The strong southward dip from the Petrolia arch is established by comparing this well with

Franklin's Stagg No. 1, Block 34, Angelina County School Land, which was abandoned in the upper part of the Ellenburger dolomite at a total depth of 5,872 feet below sea-level. The two wells are about 6 miles apart.

At least five wells in central Clay County have penetrated rocks of Ordovician age younger than Ellenburger dolomite. The presence of younger Ordovician strata south of the Electra-Muenster uplift in Montague County had been recorded in 1939. Known thickness of Viola-Simpson beds in Clay County range from less than 100 feet to more than 400 feet. These middle Ordovician strata are developed mainly in limestone facies in Clay County and, to date, have not afforded important showings of oil or gas.

Deep tests have furnished some information as to the distribution of the lower Pennsylvanian arkosic conglomerates which yield oil in Montague and Clay counties. It appears that the best development of these conglomerates within Clay County is in the central-eastern part of the county.

These conglomerates are the reservoir beds in the Hapgood pool discovered this year. This field, 3 miles northwest of the old Worsham field, was discovered on the basis of surface-structure mapping. The discovery well, Norwood's Hapgood No. 1, was completed with an initial production of 261 barrels of oil in 3 hours through $\frac{3}{4}$-inch choke from conglomerate at 5,972–5,984 feet. At the close of the year, the Hapgood pool had been localized by the completion of a failure as a west offset to the discovery and by the poor showing of south and east outposts.

A thin section was made from arkosic conglomerate in a core from 6,017 to 6,033 feet in Norwood's Hapgood No. 3, which showed the following mineral content.

Mineral Content	*Estimated Percentage*
Quartz	69
Perthite	12
Calcite	8
Orthoclase	4
Albite	3
Microcline	2
Sericite	2

The sericite is alteration of the feldspar. The calcite may be secondary to the formation of the rest of the rock. Cementation is almost completely by quartz, but some grains are cemented and slightly coated by calcite. There are fine-grained patches of quartz between larger grains. This fine-grained quartz is mainly responsible for the chalky appearance of the hand specimen.*

* Section and analysis by Roland C. Townsend, University of Wisconsin.

Another discovery in the county was made by Horton *et al.* Howard No. 1, located about $2\frac{1}{2}$ miles southeast of the Halsell field.

This well, which produces from Caddo limestone encountered at 5,461 feet, pumped 133 barrels in 24 hours on the official test. This is the second pool to find oil in the Caddo limestone in Clay County, the Ross pool, which also yields oil from this formation, having been discovered in 1939. The Horton discovery was made as a result of a seismograph survey.

The Shell Oil Company's Henderson No. 1, the discovery well of the Henderson field in southwestern Clay County, was completed in March with initial production on the pump of 287 barrels of oil in 24 hours from sand at 3,504–3,523 feet. The second well had a flowing production of 238 barrels in 24 hours from a somewhat lower sand at 3,538–3,551 feet. A third pay sand at 3,149–3,208 feet was developed by Henderson No. 3 with an official potential of 165 barrels in 3 hours. At the end of the year, 12 wells have been completed in this zone with productions ranging from 32 to 80 barrels per hour. The producing sands in this field are all of Strawn age. This field was discovered by means of seismograph exploration.

The Halsell field was extended more than ½ mile northwestward through the completion of the Bridwell Oil Company's Halsell No. A-3 and No. A-6, producing from a Strawn sand at a depth of about 4,700 feet.

In northwestern Clay County, numerous shallow tests have been drilled during 1940, which resulted in several extensions of shallow pools.

MONTAGUE COUNTY

In February, the Sinclair Prairie discovered the Bonita pool when it completed its Howard No. 1, a mile west of the town of Bonita in the northeastern part of the county. Bend limestone was topped at 5,147 feet and "pay" was found in an arkosic conglomerate at 5,241–5,249 feet, total depth. The initial production was 2,117 barrels of oil per day with 2,700,000 cubic feet of gas.

The second well, Howard No. 2, was drilled into the Ellenburger limestone disclosing the entire Bend section and opening a lower pay zone. The top of the Bend was at 5,185 feet, with limestones, shales, and arkosic conglomerates continuously to 5,803 feet, the top of the Ellenburger limestone, which was drilled to 5,852 feet, total depth. Seven-inch casing was set at 5,812 feet, through the Bend and into the Ellenburger, and conglomerate beds were tested by perforating the pipe. The horizon of the discovery well showed water, and production was found in a conglomerate at 5,443–5,458 feet after perforating. Howard No. 2 had an initial production of 269.04 barrels of oil in 3

hours through 2-inch tubing, a gas-oil ratio of 367:1, and an oil gravity of 39.9°.

At the end of the year, there were 16 oil wells: 7 wells in the upper zone, 8 in the lower zone, 1 in both zones, and 3 dry holes in the Bonita pool.

The Bonita production is from an anticline discovered by the seismograph.

In March, one month after the discovery of the Bonita pool, W. B. Omohundro opened a pool in the western part of the county after drilling a Bend section very similar to that in Sinclair Prairie's Howard No. 1. This well, the W. B. Seay No. 1, located about 3½ miles south of Ringgold, drilled Bend limestone at 5,654 feet and went into an arkosic conglomerate at 5,693 feet. This conglomerate was drilled to 5,704 feet, total depth. The initial production was 240 barrels of 47.8° gravity oil in 3 hours. By the end of the year, 7 producers and 1 dry hole had been drilled in the pool. Some of the production was from conglomerates deeper in the Bend section which here totals about 200 feet, mainly shale with stringers of conglomerate. The Ringgold pool was discovered as the result of a seismograph survey and the mapping of a northeast surface nose off the Worsham structure just across the line in Clay County.

The discovery of the Ringgold pool within a short time after the discovery of the Bonita pool, and the similarity of the two wells as to producing formations started leasing activity which extended from within Clay County, through the entire Fort Worth syncline area to the edge of the city of Fort Worth. Later developments showed the Bend conglomerates to be more erratic than indicated by the first wells. In the Rogers pool at the town of Nocona, the Bend conglomerate had been discovered and was producing within the year previous to 1940.

The Benton pool was discovered by the Sinclair Prairie's Lena Benton No. 1, one mile east of Nocona in north-central Montague County. This well drilled Bend from 5,060 to 5,200 feet and Ellenburger from 5,200 to 5,416 feet, total depth. The well was plugged back to 5,135 feet and completed, July 10, producing 59.4 barrels of oil in 3 hours, flowing through 1-inch choke on tubing. Three offsets to the discovery well were started and two had been completed in the Bend before the end of the year. Some of the Strawn sands also showed possibilities of production.

The Benton pool is on a separate closure of the same east-west trending surface structure on which is located the Rogers pool. Several

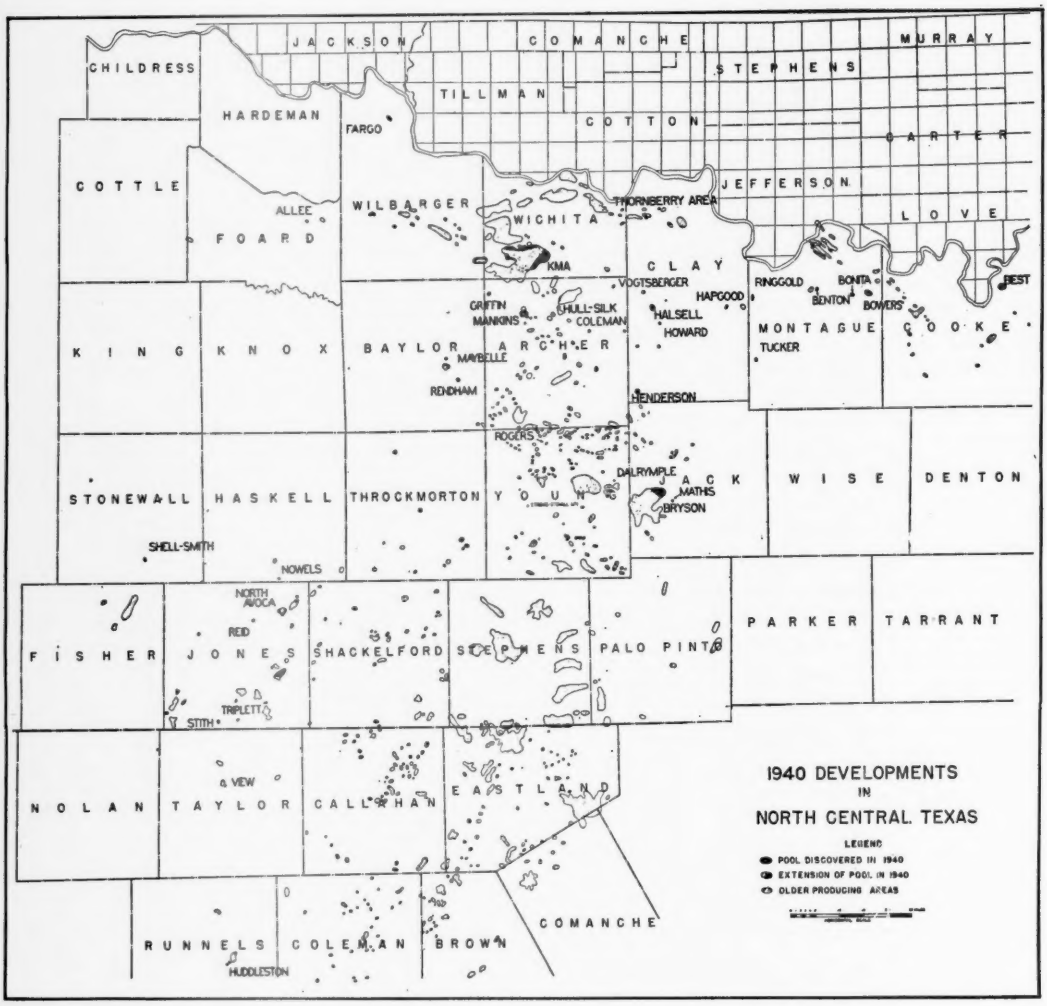

JACKSON
COMANCHE
MURRAY
CHILDRESS
STEPHENS
TILLMAN
HARDEMAN
FARGO
COTTON
CARTER
COTTLE
JEFFERSON
ALLEE
WILBARGER
THORNBERRY AREA
LOVE
FOARD
WICHITA
KMA
CLAY
VOGTSBERGER
RINGGOLD
BONITA
BENTON
BOWERS
HAPGOOD
GRIFFIN
MANKINS
HULL-SILK
COLEMAN
HALSELL
HOWARD
KING
KNOX
BAYLOR
ARCHER
MONTAGUE
COOKE
TUCKER
MAYBELLE
REDHAM
HENDERSON
ROGERS
DALRYMPLE
JACK
WISE
DENTON
STONEWALL
HASKELL
THROCKMORTON
YOUNG
MATHIS
BRYSON
SHELL-SMITH
NOWELS
NORTH AVOCA
REID
PARKER
TARRANT
FISHER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
TRIPLETT
STITH
VIEW
NOLAN
TAYLOR
CALLAHAN
EASTLAND
COMANCHE
RUNNELS
COLEMAN
BROWN
HUDDLESTON
1940 DEVELOPMENTS
IN
NORTH CENTRAL TEXAS
LEGEND
POOL DISCOVERED IN 1940
EXTENSION OF POOL IN 1940
OLDER PRODUCING AREAS

FIG. 1

previous tests, either too shallow or too far out on the flanks of the structure, had failed to produce.

One of the most interesting tests drilled in Montague County, because of the amount of geological information furnished, was the Ramsey Petroleum Corporation's Loring No. 1 dry hole, ½ mile south of the Rogers pool. The well found the base of the Pennsylvanian 1,000 feet lower than in the pool, with the Bend section of the Pennsylvanian having thickened from about 140 feet in the pool to 535 feet at its location. Dark gray to brown limestone was entered at 6,235 feet at the base of the Pennsylvanian. A core was taken from 6,457 to 6,464 feet which recovered limestone containing the trilobite *Trinucleus* sp. which occurs in outcrops of typical Viola near Bromide, Oklahoma. Simpson limestone and green shale with no sand present was drilled from 6,540 to 6,955 feet, the top of the Ellenburger. This Simpson section was the thickest drilled in the Fort Worth syncline to the end of the year.

Owens and Hultz opened the Tucker pool, 6 miles west of Bowie in the southwestern part of the county, when their Lee Tucker No. 1 was completed in November, producing 94.4 barrels of oil in 12 hours, through ¼-inch choke for 11 hours and ½-inch choke for 1 hour. Bend limestone which was drilled and cored from 6,016 to 6,050 feet, total depth, furnishes the production. The pool was found as the result of seismograph and gravity surveys. West of the discovery well, 934 feet, a second test at the end of the year had reached the Bend and found it 55 feet lower than in the discovery well, appearing unfavorable.

A new producing formation was found in the Bowers pool, 5 miles northeast of Bonita, when the Mudge Oil Company's Custers No. 1 found oil in a Strawn sand at 3,429–3,477 feet, total depth. Initial production of the well was 95 barrels in 3 hours through ½-inch choke.

Seitz-Comegys and Seitz' Harris No. 1, drilled to 6,939 feet in southeastern Montague County, near the town of Hardy, was an important test in further defining the Forth Worth syncline. This well reached the Bend at 6,551 feet and may have drilled into pre-Pennsylvanian rocks at 6,825 feet.

Gant's Laird No. 1 is an important wildcat drilled on a surface structure in the extreme southwestern part of the county. The Bend was reached at 5,690 feet and the well was stopped in the Barnett shale which was drilled from 6,546 to 6,651 feet, total depth. In the Bend were some arkosic conglomerates which failed to produce. At the end of the year the well had not been completed as attempts were being made to get production from Strawn sands which had oil staining.

WISE COUNTY

Two deep wildcats were drilling in this county at the end of the year.

The Manahan Oil Company's Collier No. 1 was shut down for orders at 6,047 feet in the Strawn. This well is in the northeastern part of the county and near the axis of the Fort Worth syncline. The well was located on subsurface geology.

Cranfill and Rodgers' McKay No. 1, in the northwestern part of the county, had reached the top of the Bend at 5,585 feet and was drilling at about 6,400 feet as the year ended. Much arkosic conglomerate was found in the Bend section, some containing good oil staining. Seven-inch casing was set at 5,796 feet to test the conglomerate section and the well was deepened, topping Barnett shale at 6,610 feet, Viola at 6,840 feet and Ordovician dolomite, the top part of which may be Simpson in age, at 6,870 feet. The well was in Ellenburger at the total depth of 7,154 feet.

COOKE AND DENTON COUNTIES

No new oil fields were discovered during 1940 in Cooke County. The Voth pool was extended by the Humble Oil and Refining Company's Hellman No. 2, producing 102 barrels daily from the 1,250-foot sand, this being a flank sand on the north side of the pool proper. Thirteen wells were completed in the extension during the year, with a total of 32 completed for the entire pool. The Best pool, discovered in 1938, had continuous development throughout 1940. Completed wells totaled 53 producers with no dry holes. The field was progressively extended in a southeasterly direction, with production coming from lenticular Strawn sands between 4,600 and 4,900 feet. One well was completed in the 4,100 foot sand.

In Denton County, one operation was in progress at the close of the year, Amon G. Carter's Allen No. 1 in the southwestern part of the county, drilling at 7,300 feet in lower Pennsylvanian beds. Freeman's Freeman No. 1, south of Krum, drilled in 1934 and deepened in 1940 by Seitz-Comegys and Seitz, was abandoned at 6,014 feet in beds of lower Strawn age.

BAYLOR COUNTY

Drilling away from the Seymour pool in Baylor County revealed the gradual east and southeast gradation down in the section of the top of the limestone reef which produces in the pool, and the practical disappearance of the reef character 4 miles northwest of the producing locality. In the Seymour pool, and at a point 2½ miles north of the pool, the top of the reef appears to cross the top limit of the Canyon

and to project a few score feet into the Cisco. Approximately 4 miles southeast of the Seymour pool, 630 feet of Canyon is penetrated before the top of the reef is reached. A mile and one-half farther southeast, one test drilled 775 feet of Canyon without reaching the top of the reef. At a point 6 miles east of the Seymour pool, a test drilled into the Canyon about 725 feet before topping the reef.

The county had two discoveries during the year, both producing from the top of the limestone reef. Southeast of the Seymour pool, 4 miles, Hall-Jordan's Green No. 1 made 186 barrels in 6 hours after acid treatment of limestone at 3,061–3,064 feet, opening the Rendham pool. Three other producers were completed in this pool during the year. This pay is in the top of the limestone reef, but is stratigraphically 650–700 feet below the "pay" in the Seymour pool. North of the Seymour pool, 2½ miles, the British American's Turbeville No. 1 opened the Maybelle pool, in limestone at 2,514–2,522 feet, making 336 barrels in 10 hours after acid treatment. This "pay" appears to be in the top of this same limestone reef and at approximately the same stratigraphic position as that in the Seymour pool. Additional tests for this locality had started as the year closed.

WESTERN COUNTIES

NEW GEOLOGICAL DATA

Mississippian limestone was found by the drill for the first time in both Stonewall and King counties during the year, resulting in one discovery well in Stonewall County.

The Superior Oil Company, of Tulsa, Oklahoma, deepened the old Marland-Drake's Martin No. 1 dry hole in the southwest corner of King County, encountering what is said to be Bend limestone from 6,516 to 6,582 feet, where Mississippian limestone was topped and drilled to 6,625 feet, total depth.

Three wells in Stonewall County penetrated Bend and pre-Pennsylvanian sediments. These wells indicate that approximately 175 feet of dark shale and limestones suggestive of Bend may be expected generally in this county. Two of these tests passed through the Mississippian limestone, 345 feet being present at the Carlile pool in the northwest part of the county, and 247 feet at a point 5 miles west of the pool. The well in the Carlile pool is believed to have drilled through Ellenburger, recording but 165 feet of this formation. From 6,700 to 6,728 feet, total depth, this test is thought to have been in pre-Ellenburger Cambrian material. In the south-central section of the county, the Shell's Smith No. 1 was completed as the discovery well in Mississippian limestone at 6,015–6,060 feet.

TABLE I

WELLS COMPLETED IN NORTH AND WEST-CENTRAL TEXAS

County	*Producers*	*Dry*	*Total, 1940*	*Total, 1939*
Archer	436	96	532	335
Baylor	14	13	27	16
Brown	23	29	52	87
Callahan	19	64	83	55
Childress	0	1	1	0
Clay	111	139	250	150
Coleman	44	13	57	35
Cooke	155	49	204	159
Cottle	0	1	1	1
Denton	1	4	5	4
Eastland	7	15	22	30
Erath	2	2	4	1
Fisher	2	1	3	5
Ford	6	2	8	2
Hardeman	0	2	2	2
Haskell	1	3	4	7
Jack	61	31	92	141
Jones	122	49	171	226
King	0	1	1	0
Knox	0	0	0	0
Montague	72	34	106	53
Nolan	1	1	2	2
Palo Pinto	8	10	18	24
Runnels	3	1	4	3
Shackelford	133	105	238	173
Stephens	19	11	30	14
Stonewall	1	2	3	5
Taylor	14	18	32	18
Throckmorton	11	14	25	30
Wichita	398	126	524	591
Wilbarger	43	23	66	68
Wise	0	1	1	4
Young	148	108	256	245
Total	1,855	969	2,824	2,486

Southwestern Cottle County had a wildcat test, the Ramsey's Lynch No. 1, which passed into igneous rock without penetrating either Mississippian or Ellenburger, but did find some pre-Ellenburger Cambrian material, probably not far from where it pinches out against the south flank of the westward extension of the Electra arch.

Farther east along the Electra axis, a few miles west of the old Thalia pool in northeastern Foard County, Foster's Allee No. 1 found Ellenburger farther west on the Electra arch than has any other test, drilling 72 feet of this formation, topped at 3,345 feet.

In northwest Childress County, on the north flank of the Red River syncline, The Texas Company's Smith No. 1 was drilled to the Ellenburger. Considerable variation in Mississippian limestone thickness in the area was demonstrated, this test having 600 feet in contrast to 300 feet in a test $4\frac{1}{2}$ miles southeast.

TABLE II

OIL PRODUCTION IN NORTH AND WEST-CENTRAL TEXAS IN BARRELS

County	*1939*	*1940*	*Total to Jan. 1, 1941*
Archer	3,927,919	6,809,305	123,422,088
Baylor	390,765	445,997	4,807,885
Brown	561,770	520,748	30,512,635
Callahan	408,068	408,922	14,389,399
Clay	821,528	966,632	9,285,779
Coleman	371,485	551,952	10,630,874
Cooke	1,959,755	2,960,391	20,121,224
Denton	2,323	4,073	10,073
Eastland	948,659	784,780	75,481,723
Erath and Comanche	84,124	270,304	
Fisher	1,056,141	822,077	12,217,522
Foard	161,010	166,196	1,814,518
Haskell	29,596	17,497	177,897
Jack	2,221,465	2,041,509	16,545,993
Jones	2,897,770	2,707,167	17,989,737
Montague	1,910,648	2,666,769	32,865,510
Nolan	1,871	717	2,588
Palo Pinto	127,914	129,681	5,286,575
Runnels	24,736	39,288	971,180
Shackelford	2,153,290	2,220,324	40,227,479
Stephens	1,231,984	1,334,599	134,191,153
Stonewall	39,198	37,119	87,711
Taylor	59,652	105,133	450,372
Throckmorton	104,143	99,652	3,410,988
Wichita	13,551,677	16,348,313	341,840,535
Wilbarger	3,063,447	3,134,458	71,516,377
Young	3,709,896	3,620,522	68,529,843
Total	41,820,834	49,214,125	966,787,658

A wildcat test, the Humble's Durham No. 1, in the south-central part of Throckmorton County, drilled into Ellenburger approximately 200 feet, having missed most, if not all, of the Marble Falls limestone and all of the Barnett shale, in contrast to conditions a short distance east where both of these units are present in substantial thicknesses.

NEW DISCOVERIES

Three miles northeast of Ballinger in Runnels County, Davis' Huddleston No. 1 opened the Huddleston pool in a lower Canyon limestone from 3,602 to 3,604 feet, making a 93-barrel producer after acid treatment. This pool was found as the result of subsurface work and had but a single producer as the year closed.

Talvez' Richards No. 1, just west of the town of View, Taylor County, opened a Cisco limestone pool. The test, drilled as a result of core-drill exploration, made a 50-barrel producer at 2,358–2,392 feet. Six producers were subsequently completed in the pool during the year.

In Jones County, the following discoveries were made during 1940: near the south line of the county, southwest of Hawley, the

Stith pool, by Danciger's Kelso No. 1, making 139 barrels from a Cisco sand at 2,336–2,340 feet; the Triplett pool in the south-central part of the county west of Hawley by Humphrey's Triplett No. 1, making 50 barrels from a Cisco sand at 2,184–2,190 feet, and subsequently a second "pay" in a Cisco limestone at 2,463–2,468 feet, which made 298 barrels after acid treatment; the Olsen pool, a mile northeast of the Avoca pool, discovered by King's Olsen No. 1, which made 263 barrels in 8¾ hours after acid treatment of the Avoca limestone at 3,209–3,211 feet; and the Reid pool northeast of Penick, which was discovered by Farrell's Reid No. 1 in a Cisco limestone at 2,570–2,572 feet, resulting in a small well after acid treatment.

The Shell's Smith No. 1, 8 miles south by east from Aspermont in Stonewall County, was the county's first Mississippian limestone producer, making 581 barrels, natural, from limestone 6,015–6,060 feet.

Haskell County's first Palo Pinto limestone production was established by Nowel's Pardue No. 1, 13 miles south of the town of Haskell. The limestone at 3,398–3,412 feet made 35 barrels after acid treatment. The pool was short-lived. Several dry holes were drilled in the vicinity and the discovery well was being plugged as the year closed.

In Foard County, a few miles west of the old Thalia pool, the Foster Petroleum Company's Allee No. 1 discovered the Allee pool, making gas and subsequently some oil from the upper part of a Canyon limestone reef at about 2,300 feet. Five producers, very small even after acid treatment, have been completed in the pool.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1081-1089, 1 FIG.

DEVELOPMENTS IN EAST TEXAS DURING 1940[1]

F. R. DENTON[2] AND R. M. TROWBRIDGE[2]
Tyler, Texas

ABSTRACT

Three oil fields were discovered and oil production was found in a gas field in East Texas during 1940.

The Hawkins field, of Wood County, which is producing from the Woodbine, is a discovery of major importance and has set in motion a large-scale leasing and geophysical program.

Routine development of proved oil fields kept completions at approximately the 1939 level. Relatively few exploratory tests were drilled.

INTRODUCTION

Drilling activity in the East Texas area (Fig. 1) during 1940 was slightly less than that in 1939. The discovery of the Hawkins field of Wood County and oil production in one gas field (Chapel Hill) renewed the interest of both major companies and independents. The total number of wells drilled during the year is 659, classified as follows.

Oil wells	485
Gas and distillate wells	60
Dry holes (fields)	42
Dry holes (wildcats)	72
Total	659

The developments in nearly all fields were mainly routine. In the East Texas field abandonments exceeded completions. Within proved areas very little drilling in search of deeper producing formations was undertaken and in no place were beds below the Travis Peak penetrated in exploratory tests.

At the end of December, 1940, the active operations in East Texas totaled 96, of which 25 were exploratory tests and 71 were in proved areas, including 28 in the East Texas field.

NEW FIELDS AND PRODUCING AREAS

Pittsburg (Camp County).—The Pittsburg field is in the southwestern part of Camp County approximately 5½ miles southwest of the town of Pittsburg. This area was proved for oil production on August 31, 1940, when the H. S. Moss *et al.* Joe Venters No. 1 was completed through casing perforations from 7,952 to 8,003 feet in a sand equivalent of the Pettit limestone section of the lower Glen Rose. The initial production of this well was 152 barrels of 42° gravity oil per day, flowing by heads. The productive area of this field is estimated to include 9,000 acres.

[1] Read by title before the Association at Houston, April 4, 1941. Manuscript received, April 28, 1941.

[2] Consulting geologists, Owen Building.

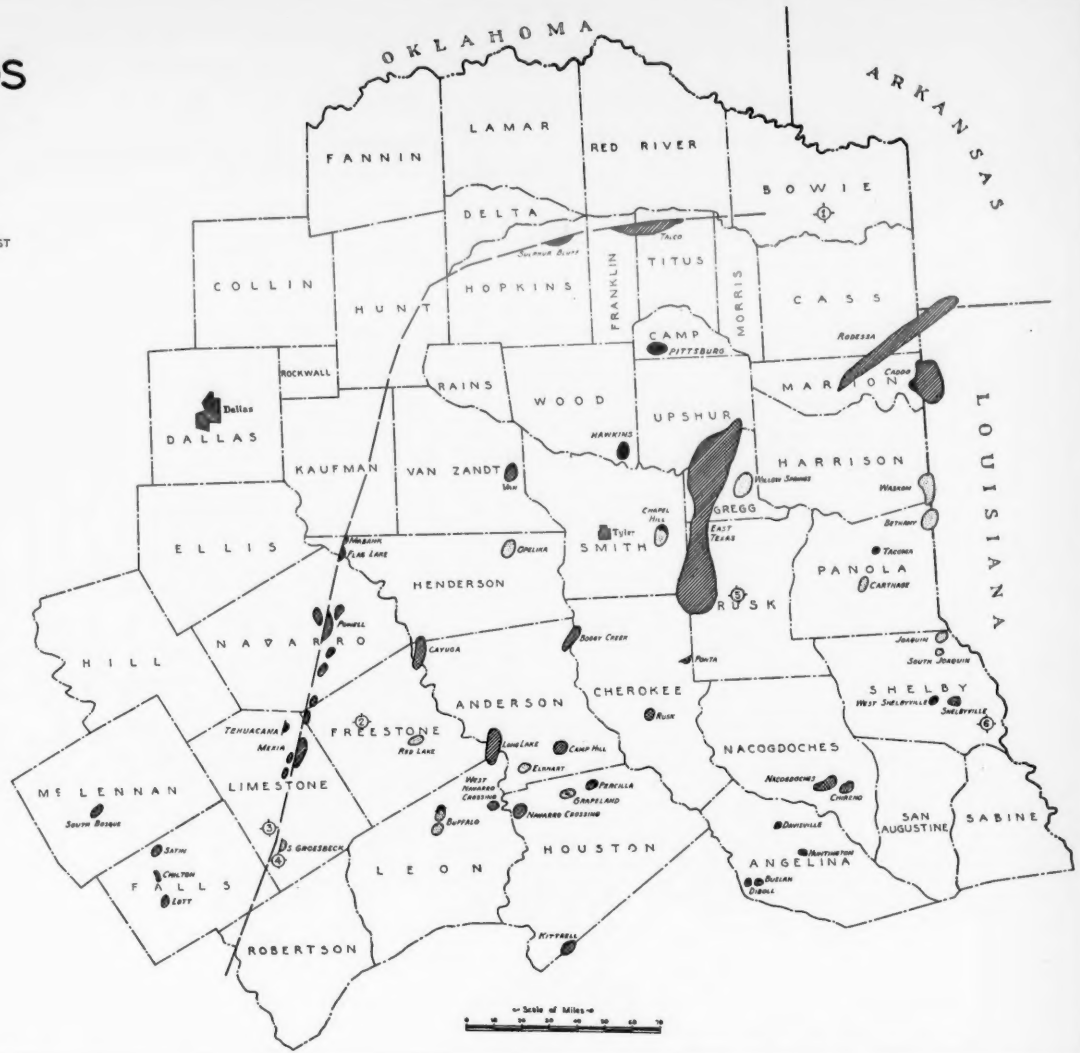
OIL & GAS FIELDS OF EAST TEXAS 1940

OIL FIELDS
OLD
NEW (1940)
(2) LOCATION OF IMPORTANT EXPLORATORY TEST (Number Refers To Text)

GAS FIELDS
OLD

GENERALIZED GEOLOGIC SECTION
EAST TEXAS

TERTIARY	EOCENE	CLAIBORNE
		WILCOX
		MIDWAY
CRETACEOUS	GULF	NAVARRO
		MARLBROOK
		PECAN GAP
		TAYLOR
		AUSTIN
		EAGLE FORD
		WOODBINE
	COMANCHE	WASHITA
		FREDERICKSBURG
	TRINITY	PALUXY
		GLEN ROSE
		TRAVIS PEAK
		COTTON VALLEY
?	?	BUCKNER
?	?	SMACKOVER
?	?	EAGLE MILLS



Interest in this area was first aroused when it was mapped as a surface "high." Later, core drilling and reflection-seismograph work confirmed the presence of a structure. A test, which was drilled to the Paluxy formation, was abandoned June 26, 1938, at a total depth of 5,710 feet, without encountering any showings of oil or gas. In December, 1939, drilling operations were resumed and the well was deepened to the Rodessa section where it was again abandoned at a total depth of 7,586 feet. After the discovery of oil in the Pettit limestone at Chapel Hill drilling was again resumed on this well and it was drilled to a total depth of 8,087 feet. A core from 7,980 to 7,990 feet recovered 7½ feet of oil sand, and the electrical log showed the presence of approximately 70 feet of sand. Casing was then run to 8,085 for testing.

The producing formation is considered by some geologists to be of Travis Peak age; however, it is the opinion of the writers that the sand is an updip (near-shore) facies of the Pettit limestone section of the lower Glen Rose.

As the year closed, the Gulf Oil Corporation's W. J. Venters No. 1, a west offset to the discovery well, was coring in the producing formation at a depth of 7,982 feet.

The cumulative production from the date of completion of the discovery well to the end of the year was 11,300 barrels. Due to the depth of the pay formation and the high drilling costs, the development in this field has been slow.

Tehaucana (*Limestone County*).—The Tehaucana field is 1½ miles southwest of the town of Tehaucana in the northern part of Limestone County. Production in this field was established June 7, 1940, when the Zephyr Oil Company completed its Carrie Peoples No. 3 in the Woodbine formation at an approximate depth of 2,650 feet. This field is on an *en échelon* fault which has approximately 200 feet of throw and is approximately 2 miles west of the Mexia graben. The initial production of the discovery well was 73 barrels of 21° gravity oil plus 90 per cent salt water, pumping. Two additional wells were completed during 1940.

The productive area of this field probably does not exceed 250 acres, and the cumulative production to January 1, 1941, was 10,125 barrels.

Chapel Hill (*Smith County*).—Two new producing formations were discovered in this field during 1940. One of these, the Pettit limestone, is productive of oil and the other, the Paluxy sand, produces gas and distillate.

The discovery of oil in the Chapel Hill field was made by the Shell Oil Company when its Henry Campbell No. 1 was completed, with an

initial production of 253 barrels of 42° gravity oil through casing perforations from 8,036 to 8,068 feet in the upper part of the Pettit limestone section. This well was originally drilled to a total depth of 8,600 feet in the Travis Peak, and casing was set at 8,160 feet after the electrical log showed good porosity in the Pettit section.

This discovery is of major significance since previous to this time only gas and distillate had been found in this member in the East Texas basin, the nearest Pettit oil production being the Shreveport field in Louisiana.

Additional drilling during 1940 showed the presence of 3 distinct porous zones within the Pettit limestone section.

A new gas-distillate horizon was opened when the Sun Oil Company's B. Moseley No. 1 was completed through casing perforations opposite the Paluxy sand section from 5,785 to 5,810 feet. The initial production of this well was 40 barrels of distillate and 880,000 cubic feet of gas through a 5/32-inch tubing choke.

Nine wells have been completed in this field, classified as follows.

Formation	*Wells*	*Dry Holes*	*Total*
Paluxy (gas-distillate)	1	1	2
Rodessa (gas-distillate)	1	0	1
Pettit (gas-distillate)	3	0	3
Pettit (oil)	3	0	3
Total	8	1	9

All of these wells, excepting the Rodessa formation gas-distillate producer, were drilled during 1940.

Cumulative production for the field is as follows.

Rodessa formation (1 well)	4,118,000,000 cubic feet of gas 295,000 barrels of distillate
Pettit limestone	10,000 barrels of distillate 42,000 barrels of oil

It is estimated that the productive acreage within this oil and gas field is 12,500 acres.

Hawkins (Wood County).—The discovery of the Hawkins field added another major Woodbine field to the East Texas area, and this discovery can be considered as the most outstanding since the discovery of the East Texas field.

This field is in the southeastern part of Wood County and was named from the town of Hawkins which appears to be located in the south-central part of the field.

The first well to produce oil from the Hawkins structure was the Manziel *et al.* F. M. Morrison No. 1, approximately 3 miles northwest of the Hawkins townsite. This well was completed, December 18,

1940, pumping 40 barrels of 19° gravity oil plus 70 per cent salt water through casing perforations from 4,909 to 4,915 feet, opposite a Woodbine sand section, being plugged back from an original total depth of 4,962 feet.

On December 19, 1940, the Jackson and Rotundi Cobb Heirs No. 1, in the Hawkins townsite, was washed in and it flowed 363 barrels of 28° gravity oil in 3 hours through a 1-inch tubing choke. An electrical survey of this well showed the presence of more than 100 feet of Woodbine sand. On the top of the Woodbine formation, this well is more than 400 feet higher than the Manziel *et al.* F. M. Morrison No. 1.

The release of the electrical log brought on a large-scale lease and royalty play which began in the Hawkins area and spread throughout the East Texas basin.

The Hawkins structure appears to be an oval dome, with a north-south axis, and its productive area may cover as much as 8,000 acres.

Early surface work in the Hawkins area indicated the presence of a structure. This structure was later confirmed by core drilling to the Navarro formation. Due to poor reflections, the attempt to use the seismograph in this area to confirm the core drill work was unsuccessful.

FIELD DEVELOPMENTS

Buffalo (*Leon County*).—The Lone Star Gas Company completed 2 additional gas wells in the Buffalo field during the year to bring the total to 9 gas wells and 1 oil well.

Caddo (*Marion County*).—During 1940 approximately 1,800 productive acres were added to the Caddo field by the completion of 36 oil wells from the Blossom sand. Nine dry holes brought the total number of wells drilled to 45. Productive wells average about 20 barrels of oil per day on initial production from a depth of approximately 2,350 feet.

Cayuga (*Anderson, Henderson, and Freestone counties*).—An increase in drilling activity in this field resulted in the completion of 16 oil wells, 7 gas wells and 3 dry holes. On January 1, 1941, there was a total of 271 oil wells and 42 gas wells producing from the Woodbine formation. Ninety-seven of the oil wells were pumping and 174 flowing their production. Cumulative Woodbine oil production to January 1, 1941, from this field is 17,939,000 barrels.

East Texas field.—Although drilling activity in the East Texas field decreased only slightly from the 1939 total, abandonments overtook completions for the year. Three hundred twenty oil wells and 7 dry holes were completed, and 348 wells were abandoned. The grand total of 942 abandonments for this field was recorded to January 1, 1941.

The 25,935 producing wells as of January 1, 1941, are classified as follows.

Flowing	17,735
Gas kick-off	87
Gas lift	916
Pumping	7,174
Dead	23

Elkhart (*Anderson County*).—The Williamson *et al.* Rogers No. 1 was the only operation in the Elkhart field during the year. This well blew out of control on February 18, 1940, in the Woodbine sand at a total depth of 5,407 feet, and it was estimated to be making 12 million cubic feet of gas per day. The well was brought under control in April and plugged and abandoned.

Flag Lake (*Henderson and Navarro counties*).—In the Flag Lake field, 4 oil wells and 1 dry hole were drilled during the year. The producing area of this field was extended approximately 2,000 feet southwest in Navarro County.

Altogether, 21 producing wells in this field were on record January 1, 1941. Seven of these wells were flowing their production and 21 were on the pump.

Grapeland (*Houston County*).—An increase in the drilling activity in the Grapeland field followed the erection of 3 recycling plants and resulted in the completion of 15 gas-distillate wells, bringing the field's total to 24 gas-distillate wells and 1 oil well.

The average daily production of distillate in this field is 5,500 barrels, which is the result of the operation of the recycling plants to which 17 gas-distillate wells are connected.

Joaquin (*Shelby County*).—In the Joaquin field, the Union Producing Company's Garrett No. B-1, which was drilled on the Louisiana side of the field, found production in the Pettit limestone, this being the first gas well completed from this member in the field.

Two gas-distillate completions in the Rodessa section on the Texas side of the field completed the 1940 drilling program.

Long Lake (*Anderson, Freestone, and Leon counties*).—Routine developments in the Long Lake field accounted for the completion of 18 oil wells, 11 combination oil and gas wells, and 8 gas wells. These wells brought the total to 37 completions for the year as compared with 28 completions for 1939.

Navarro Crossing (*Houston County*).—The addition of 2 oil wells at Navarro Crossing brought the field total to 20 oil wells, 6 gas-distillate wells, and 2 dry holes. Cumulative production for this field to January 1, 1941, is in excess of 392,000 barrels.

Opelika (*Henderson County*).—The Lone Star Gas Company took

over the operation of the Opelika field and drilled 3 additional gas-distillate wells. The average daily production from the 5 gas-distillate wells in the field is 1,130 barrels.

At the end of the year the erection of a recycling plant was practically completed, and a gas line had been laid to the Trinidad plant of the Texas Power and Light Company where gas will replace the use of lignite for fuel.

Percilla (*Houston County*).—The abandonment on March 27, 1940, of the Shell Oil Company's Darsey No. 1, at a total depth of 10,900 feet in the Pettit limestone of the lower Glen Rose, was a severe blow to the Percilla area. The only producing well in this field, the Placid Oil Company's Elliott No. 1, which was producing some oil and large quantities of salt water from the Woodbine, was abandoned in November, 1940.

Rodessa (*Cass and Marion counties*).—Completions at Rodessa dropped to a new low in 1940, with only 2 oil wells and 2 gas-distillate wells completed during the year. The abandoning of 9 oil wells and 1 gas well brought the total number of producers in the field down to 492 wells, of which 247 were pumping, 216 were flowing, and 29 were dead.

South Groesbeck (*Limestone County*).—The completion of 2 gas-distillate wells in the South Groesbeck field brought the total to 3 producing wells. The production in this field is obtained from the Pettit limestone of the lower Glen Rose at an approximate depth of 5,650 feet.

Sulphur Bluff (*Hopkins County*).—No additional wells were drilled in Sulphur Bluff during 1940. The total number of oil wells in the field remains at 73, of which 63 are showing water. Cumulative production for this field is 6,371,000 barrels.

Talco (*Titus and Franklin counties*).—In the Talco field an increase in the drilling activity during 1940 brought about the completion of 53 oil wells and 4 dry holes. Several hundred acres were added to the producing area by the extension of both the east and west ends of the field. There are 730 producing wells and 75 abandonments in the field. Of the producing wells 568 are showing water. The cumulative production for the field is 39,323,000 barrels.

Waskom (*Harrison County*).—The Waskom field at the end of 1940 had 14 gas-distillate producing wells, of which 10 were completed during the year. Production in this field is from the Pettit limestone and the Travis Peak sand, which are encountered at an average depth of 6,000 feet.

Willow Springs (*Gregg County*).—The addition of 2 gas-distillate wells in the Willow Springs field during the year brought the total to 4

wells. The gas is being used commercially as well as for gas-lift in the East Texas field. Production in this field is obtained from the Pettit limestone of the lower Glen Rose.

IMPORTANT EXPLORATORY TESTS

Bowie County.—The Shell Oil Company's W. D. Wall No. 1 (*1*)[3] located near the town of Maud in the south central part of Bowie County, was abandoned July 28, 1940, at a depth of 6,222 feet in the Travis Peak formation. This well, which was drilled on a seismograph prospect, encountered some asphaltic stains in both the upper and lower Glen Rose.

Freestone County.—The Arkansas Fuel Oil Company's O. B. Utley No. 1 (*2*), in the Stewards Mill area of northwestern Freestone County, was abandoned, November 30, 1940, in Georgetown limestone at a total depth of 4,506 feet. This test showed gas, some brown distillate, and salt water while testing the Woodbine sand section. Indications that a small structure is present bear out the reflection-seismograph work in the area. This was the first test in Freestone County to penetrate the entire Woodbine section and encounter the Georgetown limestone.

Limestone County.—Two important tests were drilling in Limestone County on January 1, 1941.

Frank Bryan *et al.* Bevill Estate No. 1 (*3*), near Horn Hill, was in the Travis Peak formation at a total depth of 5,520 feet. Operators had set 7-inch casing at 4,942 feet and as the year ended were preparing to perforate the casing and test in the Travis Peak from 4,920 to 4,940 feet, from which depth oil-stained cores were obtained. This test is on a fault which was located by surface mapping.

Amos and Harden's W. R. Hammond No. 1 (*4*), located 4 miles north of the town of Kosse, was drilled to a total depth of 5,953 feet and was bottomed in the Travis Peak formation. On January 1, 1941, with casing set at 5,858 feet, operators were preparing to perforate from 5,698 to 5,810 feet in an attempt to test the Pettit limestone section of the lower Glen Rose. Cutting samples from this section showed oil stain and an electrical log confirmed the evidence of porosity. Amos and Harden's Hammond No. 1 is located on the same fault-line structure on which the Stanolind Oil and Gas Company drilled its Norris No. 1. The latter test, which was dry and abandoned, April 17, 1938, at a total depth of 9,951 feet in conglomerate, penetrated the deepest stratigraphic section drilled in the East Texas basin. The area has been worked by surface mapping, core drill, and seismograph.

[3] Italic numerals in parentheses refer to numbers on Figure 1.

Rusk County.—Harrold *et al.* M. J. Armstrong No. 1 (*5*), approximately 3 miles southeast of the town of Henderson, was drilled on a seismograph "high." This test was abandoned, August 16, 1940, at a total depth of 7,506 feet in the Travis Peak formation after five attempts, all of which failed, to drill-stem test the upper part of the Travis Peak section. A slight oil showing was found in this section but porosity appeared to be notably low.

Shelby County.—The Superior Oil Corporation's Pickering Lumber Company No. 3 (*6*), in the southeastern part of Shelby County, was drilled to the Pettit limestone of the lower Glen Rose and was abandoned, September 11, 1940, at a total depth of 7,393 feet. Small showings of gas were encountered in both the upper and lower Glen Rose. This test was drilled on a seismograph prospect.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1090-1102, 1 FIG.

DEVELOPMENTS IN OKLAHOMA DURING 1940[1]

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ABSTRACT

A general picture of oil development in Oklahoma during 1940 does not differ materially from the pattern established by the past several years.

Total withdrawals of oil for the state during 1940 amounted to 150,072,000 barrels, a decrease of only 2.3 per cent from the production of the preceding year. Drilling operations increased slightly with 2,100 wells completed during the year. The major part of all new development was concentrated in a relatively few counties in the east-central belt of the state embracing the Seminole plateau and adjoining areas.

The Oklahoma City and Fitts pools still continued to lead the state in total annual field output.

Exploratory work was maintained at a high level and there was a noticeable increase in the number of geophysical units in operation. Following the discovery of the Cumberland pool there was for several months a very marked concentration of geophysical exploration in the south-central part of the state.

Only 230 exploratory tests were drilled during 1940 as compared with 268 during the preceding year. On the other hand there was an increase in the total number of successful exploratory wells due largely to extensions and work-overs. Seventy-six new discoveries are listed. Of these 29 are classified as new pools, and 32 as extensions. Eleven resulted from plug-back operations and 4 from deeper drilling. Stratigraphic distribution of the new discoveries was as follows.

From Pennsylvanian sands there were 37 producers, from Ordovician 21, from Siluro-Devonian 14, from Mississippian 2, and from Permian 2.

While from the standpoint of large additional proved reserves there were no discoveries of outstanding importance, the number of pools of fair quality noticeably exceeded the record of the past 2 or 3 years. Among the discoveries which have resulted in the completion of ten or more subsequent wells are the Cumberland pool in Marshall and Bryan counties, the West Hewitt extension in Carter County, the East Cromwell pool in Okfuskee County, the Dill pool extension in Seminole and Okfuskee counties, and the Prague pool in Pottawatomie and Lincoln counties.

As in the several preceding years, new discoveries during 1940 did not maintain the level of proved reserves and annual withdrawals greatly exceeded the new reserves added.

INTRODUCTION

A comparison of activities in the petroleum industry in Oklahoma during 1940 with the preceding year reveals a few changes both in magnitude of operations and results.

There was a slight increase in the total number of drilling operations, but a rather noticeable decline in the number of exploratory wells. The number of new pools discovered during 1940 was less by two than the total for the preceding year, but the number of discoveries of all classes was somewhat higher due to the excess of successful plug-backs and extension developments. Reported geophysical operations in the state during the year were slightly above the corresponding periods of 1939. While there was a small decrease in the total annual production for the state, the potential reserve of several of the new

[1] Manuscript received, April 21, 1941.

[2] Stanolind Oil and Gas Company.

pools and extensions discovered during 1940 will probably exceed by a considerable margin the reserves indicated for any of the discoveries during the preceding year.

PRODUCTION

The total production of oil in Oklahoma during 1940 was 150,072,000 barrels, a decrease of 3,428,000 barrels, or 2.3 per cent, from the total for the previous year. The decrease was probably due to a combination of readjustments in State allowables and natural decline in several of the major producing areas. The Oklahoma City pool, which still led the state in individual pool output by a wide margin, produced 35,970,314 barrels, or about 240,000 barrels more than the total for 1939.

The Fitts pool continued to show a loss. From 9,120,000 barrels during 1939 it declined to 6,246,000 during the past year. The St. Louis area also recorded a decline of approximately 2 million barrels from the total output for 1939. Annual production from other individual pools throughout the state was well below 4 million barrels.

DRILLING OPERATIONS

The number and general classification of well completions in Oklahoma during 1940 are shown in Table I. Seven of the state's seventy-

TABLE I

COMPLETIONS IN OKLAHOMA DURING 1940†

Total Completions	*Total Number*	*Oil*	*Gas*	*Dry*
Number	2,100	1,182	171	747
Percentage of total		56.3	8.1	35.6
Pool Wells				
Number	1,870	1,124	153	593
Percentage of total	(89*)	60.1	8.2	31.7
Exploratory Wells				
Number	230	58	18	154
Percentage of total	(11*)	25.2	7.8	67.0

* Percentage of total completions.
† Figure approximate on account of incomplete reports on developments in northeastern counties and on plug-back and deeper drilling operations.

seven counties accounted for more than half of the total completions. Counties in which completed operations in excess of 100 for the year were reported, are, in order of rank, Pottawatomie, Seminole, Creek, Pontotoc, Okmulgee, Carter, and Okfuskee. Few, if any, of the pools listed as discoveries during 1939 accounted for more than five completions each. On the other hand several of the new pools and new extensions discovered during the past year had reported completions by

January 1, 1941, ranging from ten to fifty wells, with others still drilling. Many of the completions in the older pools of the state were accounted for by plugging back and deeper drilling operations.

EXPLORATION AND DISCOVERIES

There was a noticeable increase in the average number of geophysical crews operating in Oklahoma during 1940. Coverage made by seismograph extended to many areas in the west half of the state with particular concentration in the Oklahoma Panhandle and in the area around the Wichita Mountains. Gravity meters and magnetometers were also employed in surveying the same areas but in addition there was considerable blanket coverage by means of these instruments over the entire western half of the state.

The discovery of the Cumberland pool early in the year on the south flank of the Arbuckle Mountains, in what constitutes essentially a new province, stimulated an intensive campaign of geophysical exploration in south-central Oklahoma and for months the area was combed by the geophysical units of every major company and thousands of acres of leasehold were acquired. To date, however, no exploratory drilling has been done on the results of the geophysical effort. Table II shows the number of units reported as operating at periodic intervals throughout the year. In addition to those listed there were reports at various times of geochemical and core-drilling activities within the state.

TABLE II

GEOPHYSICAL OPERATIONS IN OKLAHOMA DURING 1940

Total Number Instruments	*Week Ending 1-27-40*	*Week Ending 6-29-40*	*Week Ending 1-4-41*
Seismographs	15	23	20
Gravity meters	5	4	2
Magnetometers	5	6	3
Total instruments	25	33	25

Of the 2,100 wells drilled during the year, only 230, or 11 per cent, have been here classified as exploratory tests. When compared with the figure for 1939, this total represents a decrease in exploratory effort of 38 wells, or 2 per cent.

The wells were fairly well scattered throughout the more prospective areas of the state but there was the usual concentration of effort in the central counties. Table III shows the ranking order and results of exploratory work in the ten leading counties.

A comparison of this table with a similar tabulation for 1939 shows that eight of the ten counties are listed in both years. Seminole County

TABLE III

DISTRIBUTION OF EXPLORATORY TEST WELLS IN 1940 FOR TEN LEADING COUNTIES IN OKLAHOMA

County	*Total Exploratory Wells*	*Oil*	*Gas*	*Dry Holes*
Seminole	25	10	1	14
Lincoln	21	9	1	11
Okfuskee	17	7	3	7
Payne	16	5	—	11
Pottawatomie	16	6	—	10
Creek	13	6	1	6
Kiowa	11	—	—	11
Osage	11	4	1	6
Pontotoc	11	—	4	7
Logan	7	3	—	4
Total	148	50	11	87

continues to hold first position but there was some shifting in the rank of other counties, and Logan and Payne replaced Hughes and Wagoner. Of the total 230 exploratory wells listed, 148 wells, or 67 per cent, were drilled in these ten counties. As a result of the drilling of 230 exploratory tests, 29 new pools and 47 extensions or new zones were discovered during 1940. The increase in discoveries over 1939 was due to the greater number of successful extension wells, plugged-back and deeper drilling operations. Classification of the discoveries may be summarized as follows.

	Oil	*Gas*
New pools	23	6
Plug-back operations	10	1
Deeper drilling	4	—
Extensions	21	11
	58	18

In Table IV are listed all of the wells which have been here considered as discovery wells, with classification, location and other pertinent data noted.

On the map of Oklahoma (Fig. I) are indicated the location and classification of the new discoveries during the year, with a numerical reference to the tabulated list in Table IV. Seminole County with 11 new discoveries again led all other counties in the state. Lincoln and Okfuskee counties with 10 discoveries each tied for second place.

Conforming in general with the pattern observed for past years, the independent operators were again the leaders in wildcat drilling. In Table V is shown a comparison of the exploratory efforts of major companies and independents during 1940.

TABLE IV

New Pools, Extensions, and New Zones Discovered in Oklahoma During 1940

County	Map No.	Field	Class*	Section, Township, Range	Operator	Farm	Date of Completion	Depth to Producing Sand	Feet Total Depth†	Barrels Initial Production‡	Development
Carter	1	W Hewitt	Ext.	28- 4S - 2W	Turner	Ward	September	Pennsylvanian	−2,173	P—219/12 hrs.	50 wells
Carter	2	Fox	PB	21- 2S - 3W	Carter	Williams	March	Hunton, 4,898	8,088	P—oil & water	2 wells
Caddo	3	Apache	New	2- 5N-12W	Texas	Smith	November	Viola, 2,543	4,396 2,960 PB	3 million	1 well abnd.
Comanche	4	Lawton	Ext.	7- 1N-10W	Wynn	Lowe	July	Permian	−300	P—10	1 well
Creek	5	N. Tibbens	Ext.	20-15N- 9E	Springer	Colbert	October	"Wilcox," 3,639	3,657	P—75 oil, 6 wtr.	2 wells
Creek	6	Bristow	Ext.	1-15N- 9E	Young	Allen	January	Dutcher	3,360	P—22	1 well
Creek	7	E. Stroud	New	31-15N- 7E	Shell	Linihan	November	"Wilcox," 4,080	4,114 2,865 PB	Fl—177 oil, 29 water	1 well; 4 drilling
Creek	8	W. Arno	New	34-14N- 7E	Bryan	Ah-Sey	April	Prue, 2,556	2,652	Fl—140, shot	1 well; 3 dry holes
Creek	9	Edna	New	24-14N-10E	Vierson	Juedeman	January	"Wilcox," 3,171	3,197	P—83, 15 water	5 wells; 1 dry holes
Creek	10	Lincreek	Ext.	31-16N- 7E	Brauer	Airy	June	Bruner	1,114	6 million	3 wells; 2 dry hole
Creek	11	W. Olive	New	29-18N- 8E	Dempsey	Marrs	July	Prue, 2,445	2,455	P—48	1 well
Garfield	12	Enid	New	23-23N- 6W	Champlin	Kunkel	August	Mississippian, 6,072	6,939 6,190 PB	Fl—75 5 water	1 well; 1 drilling
Kay	13	SW. Ponca City	New	14-25N- 1E	Malernee	Harris	April	Oswego	4,445 TD 4,020 PB	P—17 23 water	1 well
Lincoln	14	Perkins	PB	24-17N- 2E	Portable Drlg.	Teter	April	Hunton, 4,490	4,770 TD 4,500 PB	Fl—591	2 wells; 3 dry holes
Lincoln	15	N. Agra	Ext.	28-17N- 5E	R. L. Kemp	Tanner	October	Viola, 3,886	3,935	4 million	1 well
Lincoln	16	Kendrick	New	6-15N- 5E	Summit	Cleer	April	Prue, 3,524	4,035 TD 3,555 PB	Fl—311 oil, 96 water	1 well; 2 dry holes
Lincoln	17	E. Davenport	New	7-14N- 6E	Wilcox	Murphy	September	Prue, 3,203	3,320	P—9 oil, 13 water	1 well
Lincoln	18	W. Davenport	Ext.	5-14N- 5E	Vierson *et al.*	Bell	August	Prue, 3,492	3,532	P—40 oil, 18 water	2 wells; 1 drilling
Lincoln	19	Sac & Fox	Ext.	22-14N- 6E	Black Gold	Cifer	June	Prue	3,138	P—3	2 wells
Lincoln	20	Wilzetta	DD	2-12N- 5E	Alma	Sedlacek	April	Viola Simpson dolom.	4,531	P—160	1 well; 1 drilling
Lincoln	21	Payson	New	7-12N- 5E	Mason	Crane	November	Skinner, 4,220	4,242	P—80	1 well
Lincoln	22	W. Chandler	PB	2-14N- 3E	Magnolia	Ross	August	Oswego, 3,955	4,015 PB	P—280	1 well
Lincoln	23	Skellyville	Ext.	32-16N- 6E	Youngblood	Wright	March	Hunton, 3,925	4,179 3,956 PB	P—104	1 well; 1 dry hole
Logan	24	S. Langston	Ext.	31-17N- 1E	Helmrich-Payne	McMahan	April	Simpson dolom.	5,435	Fl—62	1 well
Logan	25	Langston	PB	12-17N- 1W	Ohio	Knight	June	Hunton, 4,855	5,060	Fl—16	4 wells
Logan	26	Lovell	Ext.	3-17N- 4W	Danciger	Richards	October	Layton, 4,850	4,908	Fl—209	2 wells
McIntosh	27		New	1-12N-16E	McNutt *et al.*	Gen. Am. Life	November	Pennsylvanian	1,485	2 million	2 wells
Marshall	28	Cumberland	New	28- 5S - 7E	Pure	Little	April	Simpson	5,640 5,100 PB	Fl—4,218	12 wells; 8 drilling
Muskogee	29		New	16-13N-17E	Garrett	Escoe	June	Pennsylvanian	1,660	Gas	1 well
Okfuskee	30	Mason	New	9-12N- 9E	Burke-Greis	Dew	September	Hunton	4,127	Fl—30	1 well
Okfuskee	31	N. Castle	Ext.	34-12N- 9E	Davis	Long	May	Hunton	3,935 3,826 PB	7 million	1 well; 1 drilling
Okfuskee	32	Okemah	DD	36-11N- 9E	McIntyre	McMahan	February	"Wilcox," 3,764	3,821	P—100	2 wells
Okfuskee	33	N. Okemah	New	5-11N-10E	Texas	Cowan	August	Hunton, 3,647	3,910 3,719 PB	2 million	1 well
Okfuskee	34	N. Okemah	PB	7-11N-10E	Texas	Martin	October	Gilcrease	3,677	4-2/4 million	1 well
Okfuskee	35	N. Okemah	PB	8-11N-10E	Texas	Randles	December	Cromwell	3,650	24	1 well
Okfuskee	36	E. Okemah	New	11-11N-10E	Yoakum	Replogle	May	Cromwell, 3,167	3,177	Fl—107	5 wells
Okfuskee	37	E. Cromwell	New	36-11N- 8E	Reese Drlg. Co.	Perryman	August	Cromwell, 3,462	3,476	Fl—565	13 oil; 2 dry holes
Okfushkee	38	W. Micawber	New	11-13N- 7E	Vierson	Leonard	December	Prue, 2,606	3,590 2,619 PB	P—8 oil, 35 water	1 well
Okfuskee	39	E. Cromwell	PB	25-11N- 8E	Titus	Frank	March	Booch, 3,084	3,120	Fl—110 oil, 20 water	6 wells; 3 dry holes

TABLE IV—*Continued*

County	Map No.	Field	Class*	Section, Township, Range	Operator	Farm	Date of Completion	Depth to Producing Sand	Feet Total Depth†	Barrels Initial Production‡	Development
Okmulgee	40	Dewar	New	31-12N-13E	Staples	Sharum	January	Sd, 1,148	1,105	1 million	2 wells
Osage	41	Skiatook	New	16-22N-12E	Peters *et al.*	Osage	October	Arbuckle	2,661	10	
Osage	42	Barker	Ext.	1-23N- 7E	Peters *et al.*	Osage	September	Simpson	2,910	Swb—75 oil, 25 water	1 well
Osage	43	W. Wildhorse	New	25-22S- 9E	Norbla	Osage	July	Arbuckle, 2,423	2,449	105	2 wells
Osage	44	N. Wildhorse	DD	14-22N-10E	Peters	Osage	September	Miss. lime	1,827	Fl—1,680	1 well; 1 drilling
Osage	45	Birch Creek	Ext.	4-23N-10E	Norbla	Osage	March	Bartlesville	2,558	4 million	1 well; 1 dry
Pawnee	46	Casey	Ext.	1-21N- 5E	Alma		December	"Wilcox," 3,660	3,669	Fl—500 oil, 650 water	1 well; 1 drilling
Payne	47	Coyle	PB	13-17N- 1E	Helmerich-Payne	Collins	August	Hunton, 4,598	4,886 4,720 PB	49 425 water	5 wells
Payne	48	W. Stillwater	New	20-19N- 2E	Elson	Murphy	August	Hunton, 4,550	4,871 4,720 PB	Fl—468	2 wells; 2 dry
Payne	49	E. Broyles	Ext.	24-18N- 4E	H. P. Blackwell	Berry	March	Oswego, 2,833	3,055	Fl—130	3 wells; 1 dry
Payne	50	Avery	Ext.	17-17N- 6E	R. L. Kemp	Meyers	June	Prue, 2,875	2,897	Fl—24	1 well; 1 dry
Payne	51	Ramsey	PB	7-18N- 2E	Mid-Continent	Simpson	August	Hunton, 4,774		Fl—94	1 well
Pontotoc	52	W. Frances	Ext.	24- 5N- 6E	Sandbeck	Wagner	August	Gilcrease, 1,933	2,172	12 million	2 wells; 1 dry
Pontotoc	53	W. Frances	New	26- 5N- 6E	Kerlyn	Logan	July	Gilcrease, 2,860	2,907	46½ million	1 well; 1 dry
Pontotoc	54	W. Bebee	Ext.	31- 5N- 4E	Yingling	Newborn	July	Simpson, 2,010	2,268	11 million	1 well
Pontotoc	55	S. Frances	Ext.	2- 4N- 7E	Ramsey	McFarland	July	Gilcrease	2,602	1 million	1 well
Pottawatomie	56	Prague	New	4-11N- 6E	Berkey	Wilson	May	Skinner, 3,265	4,688 Perf. 3,261	P—70/12 hrs.	10 wells; 2 drilling
Pottawatomie	57	W. Earlsboro	New	24- 9N- 4E	Alma	Harrington	May	Hunton, 4,186	4,510 4,430 PB	Fl—150	
Pottawatomie	58	W. Earlsboro	Ext.	26- 9N- 4E	Meagel	Billington	July	Hunton, 4,250	4,508 PB	P—40, 13 water	
Pottawatomie	59	St. Louis	Ext.	25- 8N- 4E	Smith	McKeown	July	Misener & Hunton, 4,045	4,174	Fl—307 oil, 18 water	1 well; 1 drilling
Pottawatomie	60	Romulus	New	6- 7N- 4E	Smith	Brown	August	Hunton, 3,960	3,993	Fl—377	6 wells; 4 drilling
Pottawatomie	61	W. St. Louis	Ext.	29- 7N- 4E	Burns	Henry	April	Viola, 4,232	4,312	140/8 hrs.	1 well; 2 dry holes
Seminole	62	Dill	Ext.	3-11N- 8E	Dropplemen	Gahajass	May	Cromwell, 3,550	4,160 PB	2,880	21 oil; 3 dry; 8 drilling
Seminole	63	N. Wewoka	New	32- 9N- 8E	Stanolind	Aldridge	March	"Wilcox," 4,370	4,394	Fl—4,421	2 wells; 1 dry hole
Seminole	64	Fish	Ext.	18- 7N- 8E	Winnie	Jackson	January	"Wilcox," 4,189	4,195	Fl—360	3 wells
Seminole	65	W. Seminole	New	30- 9N- 6E	Amerada	Campbell	December	"Wilcox," 4,220	4,272	453	2 wells
Seminole	66	N. Seminole	New	15- 9N- 6E	Stanolind	Grisso	October	Senora, 2,892	2,924	Fl—75	2 wells
Seminole	67	W. Little Riv.	PB	21- 7N- 6E	Newsome	Choya	October	Calvin, 2,326	2,339	Fl—42	2 wells
Seminole	68	W. Bethel	Ext.	13- 9N- 7E	Mason	Rich	March	Senora, 2,168	2,294	3½ million	1 well
Seminole	69	SE. Little Riv.	PB	30- 7N- 7E	Norvel Patterson	Thlocco	July	Senora, 2,274	2,275	Fl—90	2 wells; 4 dry holes
Seminole	70	N. Bebee	DD	3- 5N- 5E	Culver Shepherd	Swan	June	Viola	2,906	10	
Seminole	71	Fish	Ext.	18- 7N- 8E	Mid-Continent	Ferguson	September	Gilcrease, 3,200	3,471 PB	Fl—50 oil, 1—12 million	2 wells
Stephens	72	Loco	Ext.	13- 3S- 5W	Pace	Miller	November	Sd	952	12	1 well
Texas	73	Optima	Ext.	4- 3N-17E	Peerless	Hoffberger	October	Permian	2,725	13 million	1 well
Tillman	74	Hatler	Ext.	32- 2S-17W	Johnson	Longacre	August	Canyon, 2,998	3,267	90 oil, 70 water	1 well; 1 dry hole
Tulsa	75	Alsuma	Ext.	26-19N-13E	Daisy Drlg. Co.		April	Simpson, 2,294	2,251	3 million	1 well
Wagoner	76	Wagoner	Ext.	16-18N-17E	Jordan	Merri-weather	November	Tyner	903	1 million	1 well

* New: new pool; DD: deeper drilling; PB: plugged back; Ext.: extension.
† PB: plugged back; TD: total depth; Perf.: perforated.
‡ P: pumped; Fl: flowed; million: million cubic feet of gas

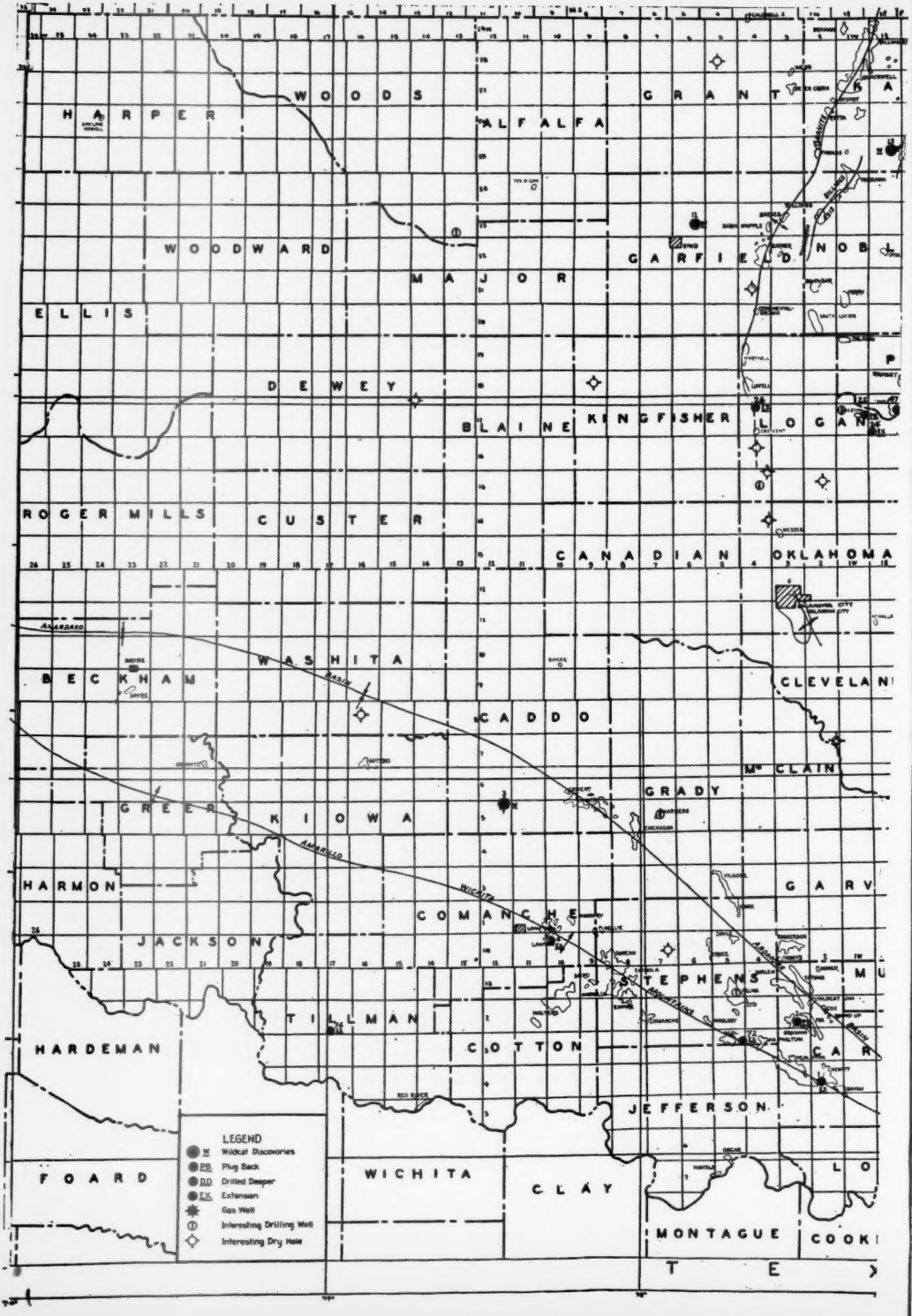
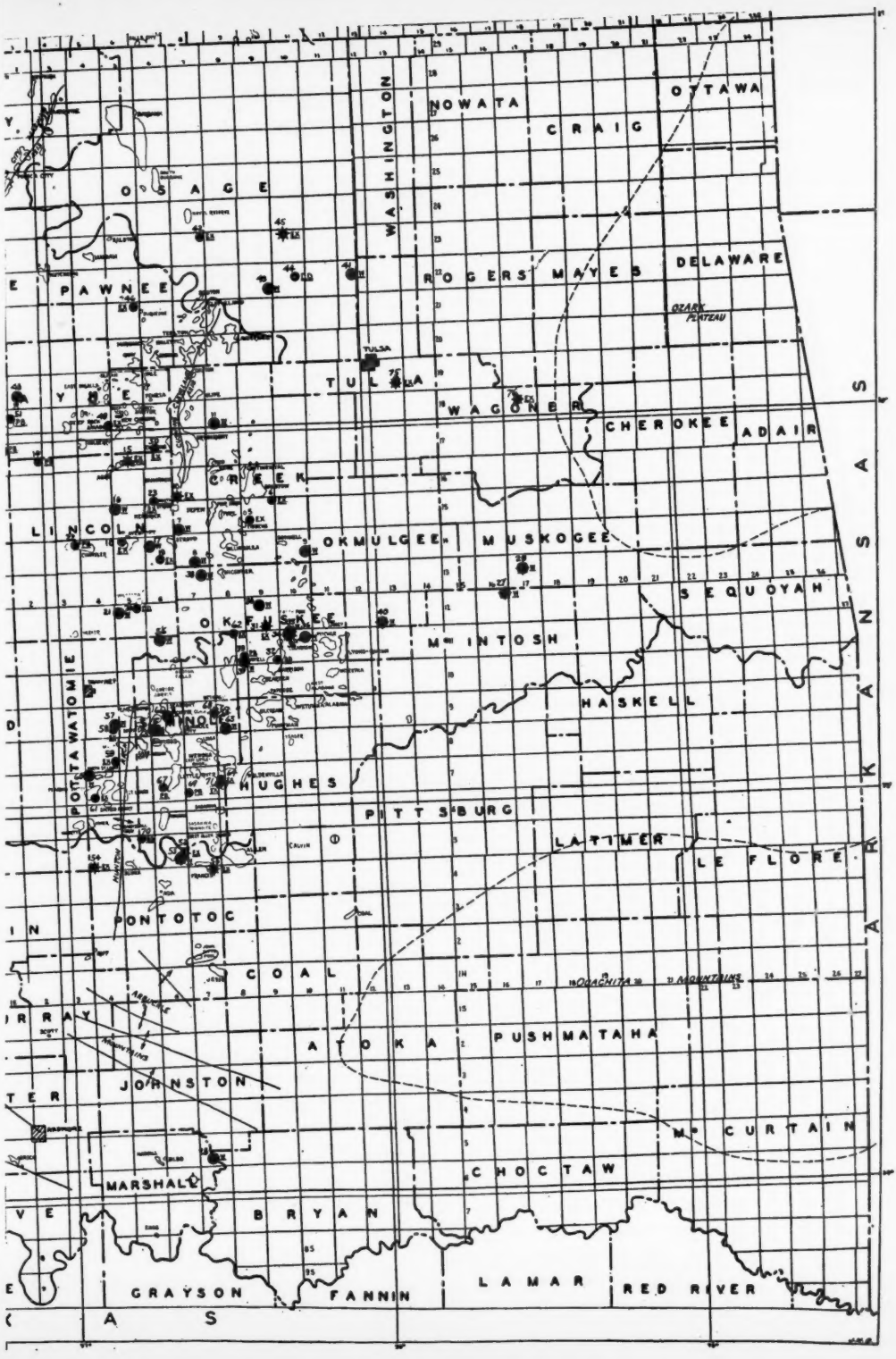


FIG. 1.—Map of Oklahoma showing location and classification of new discoveries



during 1940, with a numerical reference to the tabulated list in Table IV.

TABLE V

COMPARISON OF EXPLORATORY RESULTS OF MAJOR COMPANIES AND INDEPENDENTS IN OKLAHOMA DURING 1940

	Total	*Major Companies*	*Independents*
Total Exploratory Wells Drilled	230	32	198
Total oil wells	58	11	47
New pools	23	5	18
Plug-backs	10	5	5
Deeper drilling	4	—	4
Extensions	21	1	20
Total gas wells	18	3	15
New pools	6	2	4
Plug-backs	1	1	—
Deeper drilling	—	—	—
Extensions	11	—	11
Dry holes	154	18	136

Of the total 230 exploratory wells drilled, independents were responsible for 198 wells, or 86 per cent, while major companies completed only 32 wells, or 14 per cent. A comparison of successful results, however, is somewhat more in favor of the major companies. With a total of 32 tests drilled, 14 wells, or 44 per cent, were completed as discoveries, while independents recorded success in only 62 wells of the total of 198, a ratio of 31 per cent.

In comparison with results in previous years, the ratio of discoveries to total wells drilled is unusually high for both majors and independents.

In Table VI is shown the stratigraphic distribution of the productive zones revealed by the new discoveries during 1940.

TABLE VI

STRATIGRAPHIC DISTRIBUTION OF OKLAHOMA DISCOVERIES DURING 1940

	Total Discoveries	*Oil*				*Gas*			
		New Pools	*Plug-Back*	*Deeper Drilling*	*Extensions*	*New Pools*	*Plug-Back*	*Deeper Drilling*	*Extensions*
Permian	2	—	—	—	1	—	—	—	1
Pennsylvanian	37	11	5	—	11	4	1	—	5
Mississippian	2	1	—	1	—	—	—	—	—
Siluro-Devonian	14	4	5	—	3	1	—	—	1
Ordovician	21	7	—	3	6	1	—	—	4
	76	23	10	4	21	6	1	—	11

Pennsylvanian sands led in both new pools and extensions with the Ordovician, embracing Viola, Simpson, and Arbuckle, ranking second.

INTERESTING NEW DISCOVERIES

While subsequent development has proved that many of the discoveries recorded for the year are of limited extent and of minor importance as a source of added oil reserves, still the number of new pools and extensions of reasonably good quality which were opened

during 1940 surpasses that of the several years preceding. Only a few of the more outstanding discoveries are discussed in detail.

CUMBERLAND POOL, MARSHALL AND BRYAN COUNTIES

One of the most interesting if not the most important discovery of the past several years was the Cumberland pool in Marshall and Bryan counties. The discovery well, The Pure Oil Company's Quentin Little "A" 1, in the center of the W. ½, NE. ¼, SE. ¼ of Sec. 28, T. 5 S., R. 7 E., was completed in April with an initial daily production of 4,218 barrels of high-gravity oil. Viola limestone was encountered in the Little No. 1 at a depth of 3,925 feet and the top of the Bromide at 4,470 feet. Saturated sands were found in the Bromide-Tulip Creek section at depths of 4,760–4,815, 4,952–4,964, 5,005–5,017, and 5,088–5,098 feet. Several drill-stem tests were taken through this section with favorable results. The McLish limestone was topped at 5,107 feet and drilling continued into the Oil Creek at a total depth of 5,640 feet. The basal McLish sand at 5,502–5,595 feet tested salt water. The well was then plugged back to 5,100 feet. Casing had been set at 4,857 feet below the first Bromide sand which contained gas. The well was completed as a producer from sands between 4,857 feet and 5,100 feet, opening the first major pool on the south flank of the Arbuckle Mountains.

Location for the discovery well was made by The Pure Oil Company on a block of approximately 20,000 acres, following exploratory work with magnetometer and seismograph. The structure as partly defined by development to date appears to be a rather symmetrical elongate anticline with steep flanking dips. The axis of the closure is aligned northwest and southeast parallel with the trend of the Arbuckle Mountains and less than 2 miles from the major fault zone which defines the south flank of the mountain uplift. Since basement granite is present on the north or upthrown side of the fault beneath a thin mantle of Trinity the vertical displacement must be not less than 10,000 feet.

The probable productive area of the pool is controlled entirely by The Pure Oil Company. Development has been carried on in a conservative manner, with wells located on 20-acre spacing. By January 1, 1941, twelve producers had been completed and there were a number of active drilling operations. The pool produced approximately 400,000 barrels during 1940 with an average daily production during December in excess of 3,000 barrels. Water has been encountered in some of the flank wells and fairly definite water levels established in the several sands. On the basis of projected water levels and structural dips, the productive limits of the field should be 1,000–1,500 acres. Of con-

siderable importance in the future development and operation of the Cumberland pool is the fact that much of the productive acreage lies within the basin of the Dennison Dam.

NORTHWEST DILL POOL EXTENSION, SEMINOLE AND OKFUSKEE COUNTIES

The discovery well in the Northwest Dill area was the Droppleman *et al.* Gahagan No. 1, in the northeast corner of Sec. 3, T. 11 N., R. 8 E. The well was drilled primarily to test the Hunton limestone, main producing formation of the Dill pool. When this zone was encountered low and barren, casing was set at 3,655 feet through a showing in the Cromwell sand topped at 3,550 feet. After operators perforated 15 feet of the Cromwell, the well flowed 2,880 barrels of 36° gravity oil in 24 hours. By January 1, 1941, 21 producers and 3 dry holes had been completed and there were 8 active drilling operations. Average initial production of the wells has been in excess of 1,000 barrels per day.

Though this area has been classified as an extension, it might well be considered as a new structure since it is separated from the old Dill pool by a fault downthrown toward the west. The structure is an asymmetrical anticline trending slightly east of north parallel with the fault. The discovery well is located near the south limits of the producing area.

WEST HEWITT EXTENSION CARTER COUNTY

On the west flank of the Hewitt pool, Turner *et al.* completed the Ward No. 1, whose initial production was 219 barrels in 12 hours from a Deese sand at 2,173 feet. This discovery was made in September and so vigorous was the resulting drilling campaign that by January 1, 1941, approximately 50 wells had been completed on rather close spacing with a daily production in excess of 3,000 barrels per day. Structural information on this extension is not available. Accumulation may be due to the wedging-out of flank sands or to the separation of this area from the main pool by faulting.

PRAGUE POOL, POTTAWATOMIE AND LINCOLN COUNTIES

Berkey *et al.* Wilson No. 1, Sec. 4, T. 11 N., R. 6 E., the discovery well of the Prague pool, was drilled as a "Wilcox" test. When this formation was proved barren at a total depth of 4,688 feet, casing was perforated into the Skinner sand zone at 3,265 feet, and the well completed, pumping 70 barrels in 12 hours. By January 1, 1941, there were 10 producers and 2 drilling operations in the pool.

Accumulation appears to be the result of a combination of favorable local sand conditions and some structural terracing.

IMPORTANT DRY HOLES

In Table VII are listed a few of the more important outlying dry holes completed during 1940.

TABLE VII

IMPORTANT DRY HOLES DRILLED IN OKLAHOMA DURING 1940

Operator	*Well*	*Location*		*Feet Total Depth*	*Probable Reason for Drilling*	*Stratigraphic Penetration*
		County	*Sec. T-R*			
Gulf	Quales	Stephens	23- 1N- 7W	10,157	Geophysical	In Pennsylvanian Dornick Hills
McGraw	Neff & Godfrey	Marshall	14- 6S - 6E	5,890	Surface and seismograph	145 feet into Arbuckle
Continental	Kretzechmar	Grant	28-28N- 5W	5,509	Geophysical	Into "Wilcox" sand
Fain Drlg. Co.	Schnakenberg	Garfield	21-21N- 4W	6,542	Seismograph	Into "Wilcox" sand
Kerlyn	Chitwood	Logan	15-16N- 4W	6,698	Subsurface and seismograph	Into Second "Wilcox"
Kerlyn	Cavanaugh	Logan	1-15N- 4W	6,732	Surface and subsurface	Into Second "Wilcox"
Eason	Wells	Logan	15-16N- 2W	5,920	Seismograph	Into Second "Wilcox"
Continental		Oklahoma	24-14N- 4W	6,785	Seismograph and subsurface	Into Second "Wilcox"
Delaney	Footman	Cleveland	12- 7N- 2W	7,796	Subsurface	Into "Wilcox"
Anderson-Prichard	Geis	Kingfisher	15-18N- 9W	9,404	Geophysical	Into Second "Wilcox"
Magnolia	Feikes	Dewey	31-18N-14W	9,475	Geophysical	Into lower Pennsylvanian
Continental	School Land	Washita	16- 8N-16W	8,000	Seismograph	In Pennsylvanian

In the Anadarko basin 2 more deep failures were recorded. The Gulf Oil Corporation reached a total depth of 10,157 feet in Quales No. 1, Sec. 23, T. 1 N, R. 7 W., Stephens County, without getting through the Pennsylvanian sediments. The Continental Oil Company completed the School Land No. 1, Sec. 16, T. 8 N., R. 16 W., at a total depth of 8,000 feet still in Pennsylvanian. This test is located about 25 miles southeast of the famous Proctor well completed by the same company in 1939 at a total depth of 14,582 feet. The Magnolia Petroleum Company completed one of the outlying wildcats in its Feikes No. 1, Sec. 31, T. 18 N., R. 14 W., Dewey County. This test was abandoned in lower Pennsylvanian at a total depth of 9,475 feet after a reported gas blowout. Several more dry holes were completed along the granite ridge trend between the Edmond and Crescent pools.

IMPORTANT WILDCATS STILL DRILLING AT CLOSE OF 1940

A few of the more important wildcat wells still active at the close of 1940 are listed in Table VIII. Two of these tests, as noted under the "Remarks" column, have since been completed as pool openers. Two more have been abandoned as failures and the other two are still active.

TABLE VIII

IMPORTANT WELLS STILL DRILLING AT END OF 1940

Operator	*Well*	*County*	*Location Sec. T-R*	*Feet Drilling Depth*	*Probable Reason for Drilling*	*Remarks*
E. W. Hamilton *et al.*	Donahue	Logan	7-17N- 1W	Loc.	Seismograph	Completed as pool opener in March
Magnolia	McKay Heirs	Hughes	16- 5N-11E	5,852	Seismograph and surface	Completed as Cromwell gas well in March
Skelly	Robberson	Stephens	35- 1S - 5W	2,170	Seismograph and subsurface	Deep test
I.T.I.O.	Cronkite No. 1	Logan	22-15N- 4W	6,535	Geophysics	Drlg. in Woodford
Gulf	Hess	Woods	33-23N-13W	7,580	Geophysics	Drlg. in Kinderhook
Atkinson *et al.*	Jelks	Grady	22- 5N- 7W	3,944	Surface and subsurface	Deep test

CONCLUSION

In spite of the rather impressive list of new discoveries and extensions made during 1940 and the favorable quality of some of these areas as reflected by subsequent development, Oklahoma again failed to maintain the level of proved reserves and, as in the several years preceding, the total reserves were reduced by many millions of barrels. The generally favorable situation as regards available pipe-line outlets combined with rather liberal per-well allowables, and the fine quality of the crude oil, still make Oklahoma an attractive area for the prospector. This condition is reflected in the relatively high level at which exploratory work is being maintained.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1103-1113

DEVELOPMENTS IN NORTH MID-CONTINENT IN 1940[1]

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ABSTRACT

Kansas experienced a year of increased activity both in development and wildcatting, but results in the latter were relatively less fruitful. The number of total completions increased 33.9 per cent over 1939 and the dry hole percentage dropped from 24.7 per cent to 20.3 per cent. Initial oil production per well fell slightly from 1,577 barrels to 1,561 barrels, but the completion of 1,421 oil wells developed about 2,200,000 barrels of new potential compared with 1,500,000 barrels of new potential in 1939. Despite less activity in the Forest City basin, wildcatting increased from 95 completions in 1939 to 145 in 1940, but no important pools have yet been developed among the 23 discoveries. The most promising, as well as the most important of these pools, is the Ray pool in Phillips County, which previously had had but one small pool. In the Forest City basin, an oil and gas discovery of doubtful value was made in the McLouth pool of Jefferson County. The Bemis-Shutts, Burnett, Bornholdt, Trapp, Hall-Gurney, and Zenith pools accounted for 42 per cent of the new wells and 61 per cent of the new potential. Numerous extensions to old pools were made and many pools were joined.

In Nebraska, the Falls City pool of Richardson County was the scene of the completion of 25 oil wells and seven dry holes. This pool produces low-gravity oil from a dolomite in the upper part of the Devonian that is generally referred to as "Hunton." The wells respond favorably to acid treatment, but water encroachment is rapid and it is doubtful that "Hunton" production in this pool will ever be of much importance. Twenty-eight wildcat dry holes and one small oil well were completed elsewhere in Nebraska in 1940.

The Forest City basin play in Missouri resulted in the completion of seven additional deep failures and northeastern Missouri drew seven dry holes. There was also some moderately successful shallow gas development in the area east of Kansas City. There was a little intermittent drilling in Iowa, and some in the Dakotas, but the latter states were the scene of much checkerboard leasing and exploratory work.

INTRODUCTION

Continued exploitation of western Kansas oil reserves was the chief feature of developments in the north Mid-Continent region in 1940. Wildcatting in all states was relatively disappointing. The development of a low gravity oil field at Falls City, Nebraska, was the most fruitful result of drilling in that state, but only one discovery resulted from the twenty-nine wildcats drilled. The Forest City basin play in northeastern Kansas and northern Missouri was nearly dead; one small oil and gas field in Jefferson County, Kansas, was the only favorable result. Western Nebraska and the Dakotas received much attention from many companies in 1940, but very little drilling was done.

KANSAS

DRILLING ACTIVITY

Drilling activity in Kansas for the last 3 years is summarized in Table I.

[1] Read before the Association at Houston, April 4, 1941. Manuscript received, April 30, 1941.

[2] Darby Petroleum Corporation.

TABLE I

	1940	Per Cent	1939	Per Cent	1938	Per Cent
Oil wells	1,421	76.4	983	70.8	1,122	69.0
Gas wells	61	3.3	62	4.5	62	3.8
Dry holes	377	20.3	343	24.7	442	27.2
	1,859		1,388		1,626	

The above figures for 1940 do not include recompleted wells. In this classification there were 112 oil wells with a potential of 132,039 barrels, two gas wells with a capacity of 52,700,000 cubic feet, and 20 dry holes, three of which were used as water disposal wells.

It is noteworthy that although drilling increased 33.9 per cent and wildcatting increased 50 per cent, the dry-hole percentage fell from 24.7 to 20.3. There was an increase in the drilling of stratigraphic tests and tight holes during the year.

Comparative results of drilling for the past 3 years are shown in Table II.

TABLE II

Year	Oil Wells	Barrels Potential	Barrels Average Potential	Gas Wells	Barrels Capacity	Barrels Average Capacity
1938	1,122	1,355,507	1,208	62	778,763,000	12,561,000
1939	983	1,548,772	1,577	62	1,280,984,000	20,661,000
1940	1,421	2,218,720	1,561	61	1,292,201,000	21,183,000

The completion of more than 2 million barrels of new potential in 1940 represents the largest new potential added to the state in any one year and resulted in a new peak potential for the state at the end of 1940. At that time the official potential of the state was 7,068,002 barrels per day compared with 4,711,054 barrels at the end of 1939. The number of wells rose to 20,673 from 19,649. It becomes evident early in 1941 that, unless drilling is accelerated, Kansas will not be able to continue to increase its total potential at this rate. In fact early in 1941 several large fields, including Ritz-Canton, Wherry, and Wellington, were dropped from the proration report, and it is doubtful that, as allowables in other fields are increased, the potential can be maintained at these figures.

LEASING ACTIVITY

Renewal of expiring leases constituted a large part of the leasing activity throughout the year. Many of them were in areas far enough from production to call for nominal prices and the number of farm-outs

of close-in acreage due to inability to renew at reasonable prices was less than in 1939. Many leases and blocks in the Salina basin and Forest City basin were dropped during the year, although there is still much land, drawing relatively low rentals, in these areas that is still held. Certain companies, as a matter of policy, reduced their holdings in all areas, but likewise other more venturesome companies increased their checkerboards in carefully chosen spots. In the last quarter an active checkerboard play took place in Phillips, Norton, Decatur, Graham, and Rooks counties as well as several counties in south-central Nebraska. This play was caused by the discovery of the Ray pool in T. 5 S., R. 20 W., Phillips County, which was the most important and most promising new pool in 1940. Little additional leasing was done in northeastern Kansas in 1940.

PRORATION REGULATIONS

There were few important changes in the rules and regulations governing proration in 1940. Wider spacing and new patterns of development brought up some interesting problems but these apparently have been solved to the satisfaction of everyone. In January, 1941, about 2,100 of the more than 6,600 prorated wells shown on the proration report were located on a spacing of more than 10 acres, while in May, 1940, less than 1,200 such wells were shown.

The average daily allowable per prorated well fluctuated as follows.

	Barrels		*Barrels*
January	21.2	July	19.0
February	22.3	August	19.9
March	22.4	September	22.7
April	18.7	October	21.4
May	19.9	November	21.9
June	19.1	December	21.8

Kansas produced 64,824,721 barrels of oil in 1940, compared with 58,768,943 barrels in 1939 and 58,230,032 in 1938. December runs of 187,697 barrels per day show a decided increase over the daily average of 173,573 barrels in December, 1939. Early in 1941, Kansas daily average production had climbed to nearly 200,000 barrels and is expected to exceed that figure substantially throughout the year.

WILDCATTING

Despite less activity in the Forest City basin in 1940, wildcat drilling increased about 50 per cent over 1939, but no substantial increases in reserves can be attributed to any of the twenty-three new oil and gas pools found during the year. Exploration as well as development spread northwestwardly along the Central Kansas uplift in

1940. There were many extensions of old pools and many of the discoveries classed as new pools in Table V will eventually be joined with older fields. There was a slight tendency to drill more wells in outlying counties than in the past 5 years but results were disappointing except for the discovery of the Ray pool in Phillips County.

Not only were the new pools of 1940 disappointing in the amount of reserves discovered, but developments around the 1939 discoveries also failed to show that another Trapp, another Bemis, or another Silica had been found. Of the sixteen new oil pools discovered in 1939, at the close of 1940 two had been abandoned, one was shut in without an outlet, and twelve contained a total of only 54 wells. The other pool, Bornholdt North, had been joined to Bornholdt and the combined area had been developed into an important field. It is obvious that a more aggressive wildcat program is needed for Kansas in 1941.

Table III classifies all wildcat wells in western and northeastern Kansas in 1940 according to the method of location.

TABLE III

SUMMARY OF WILDCAT ACTIVITY, 1940, WESTERN, CENTRAL, AND NORTHEASTERN KANSAS

	Producing	*Dry*	*Total*
Non-geological			
Chance	3	61	64
Expiring leases or unknown	4	4	8
Geological			
Surface	2	9	11
Subsurface	6	15	21
Core drill	2	9	11
Seismograph	3	10	13
Surface and core drill	0	4	4
Core drill and subsurface	2	2	4
Core drill and seismograph	0	4	4
Torsion balance	0	1	1
Surface and subsurface	0	1	1
Surface and seismograph	0	1	1
Electrical survey	0	1	1
Magnetometer and subsurface	1	0	1
	Success Percentage		
Non-geological	9.7	7	65	72
Geological	21.9	16	57	73

Any classification such as that shown in Table III is bound to be somewhat arbitrary and based on individual opinion and information. However, the unmistakable conclusions that can be drawn from Table III are that scientific exploration for oil in 1940 in Kansas was decidedly more fruitful than random drilling and that all the tools of the prospector, whether geological, geophysical or geochemical were

necessary to discover a relatively small amount of new reserves. It may be truthfully argued that there was very little rank wildcat drilling in western Kansas last year. However the one company that did the greater part of this drilling, the Cities Service Oil Company, drilled the most dry holes and paradoxically discovered the most promising and most important pool of the year.

Table IV shows a comparison of wildcatting 1938, 1939, and 1940.

TABLE IV

Year	*Oil and Gas Wells*	*Footage*	*Dry Holes*	*Footage*	*Total Wells*	*Footage*
1938	43	148,050	129	478,389	172	626,439
1939	21	67,259	74	258,031	95	325,290
1940	23	75,142	122	408,887	145	484,029

The average discovery well in 1940 had a depth of 3,267 feet compared with 3,202 feet in 1939. The average dry hole in 1940 was drilled 3,351 feet compared with 3,487 feet in 1939. The deepest wildcat was drilled to 6,071 feet; only five reached below 5,000 feet and only eighteen exceeded 4,000 feet.

NEW POOLS

Table V lists the new pools discovered in Kansas in 1940 as named by the nomenclature committee of the Kansas Geological Society. The most important is the Ray pool in T. 5 S., R. 20 W., Phillips County, discovered by the Cities Service Oil Company on core-drill information. To the first of March, 1941, eight wells had been completed in this pool in the basal sand with a combined potential of 19,528 barrels. Locally the Arbuckle dolomite is absent so that Pennsylvanian beds rest directly on basal sand, which in turn overlies pre-Cambrian granite. It is expected that a pool similar to the Gorham field will be developed here. The chief importance of the pool lies in the fact that it is not only the first prolific pool to be found in Phillips County but it extends profitable production 30 miles northwest and within 30 miles of the Nebraska line. The wells produce 32° oil which is better than that found in the near-by Rooks County pools in the pre-Pennsylvanian beds.

The Penokee pool in Graham County is the second for that county but its importance is unknown at present due to the lack of outlet and any adequate test of the sole well drilled to date. Early in March, 1941, it was completed with a potential of 216 barrels of 42° oil from Lansing-Kansas City "pay" at 3,740–3,756 feet after having been drilled to a total depth of 4,104 feet in Arbuckle dolomite. Both the

TABLE V

LIST OF CORRECTLY ADOPTED NEW AREAS OF PRODUCTION DISCOVERED IN KANSAS DURING 1940

	Field	*County*	*Sec., Twn., Rge.*	*Depth in Feet*	*Discovery Date*	*Producing Formation*	*Method of Exploration*	*Barrels Potential*
1.	Bedford	Stafford	21-23-12W	3,854	8-18-40	Arbuckle	Seismograph	2,700
2.	Bemis-Shutts, West	Ellis	20-11-17W	3,391	9-23-40	Arbuckle	Chance	3,000
3.	Bird	Barton	33-18-15W	3,510	4-22-40	Basal sand	Subsurface	27
4.	Bitikofer	McPherson	1-20- 1W	2,916	5- 8-40	Mississippian limestone	Chance drilling and subsurface	49
5.	Davidson, Northeast	Russell	34-15-11W	3,313	12- 7-40	Sooy conglomerate	Chance	1,254
6.	Driscoll	Russell	30-15-11W	3,323	6-26-40	Sooy conglomerate	Subsurface	646
7.	Greenvale, Northwest	Russell	32-14-12W	2,956	11-26-40	Lansing-Kansas City	Expiring leases	319
8.	Hammer	Barton	35-19-12W	3,370	8-20-40	Arbuckle	Subsurface and magnetometer	441
9.	Henne	McPherson	21-17- 1W	2,661	11- 5-40	Mississippian limestone	Subsurface	495
10.	Herzog	Ellis	30-13-16W	3,465	5-30-40	Arbuckle	Subsurface	3,000
11.	Karber	Barton	7-19-10W	3,350	10- 9-40	Arbuckle	Subsurface	280
12.	Lewis	Russell	28-14-12W	2,329	9-27-40	Wabaunsee	Expiring leases	1,463
13.	McLouth	Jefferson	4-10-20E	1,596	6-15-40	Mississippian limestone	Surface	38
14.	Mahoney	Russell	8-14-12W	2,985	6-26-40	Lansing-Kansas City	Surface	559
15.	Penokee	Graham	11- 8-24W	4,104	11- 4-40	Lansing-Kansas City	Core drill	
16.	Prusa, Southeast	Barton	34-16-11W	3,402	4- 7-40	Arbuckle	Chance	
17.	Ray	Phillips	32- 5-20W	3,603	8-15-40	Basal sand	Core drill	2,135
18.	Riley	Stafford	28-23-11W	3,645	8-25-40	Lansing-Kansas City	Seismograph	1,342
19.	Stafford	Stafford	15-24-12W	3,886	8- 4-40	Viola limestone	Seismograph	3,000
20.	Stoltenberg, West	Ellsworth	17-16-10W	3,384	3-26-40	Arbuckle	Expiring leases	566
21.	Stoltenberg, Southwest	Ellsworth	20-16-10W	3,349	7- 7-40	Arbuckle	Expiring leases	240
22.	Wondra	Barton	15-17-12W	3,325	1-21-40	Lansing-Kansas City	Subsurface	101
	Total footage of oil discoveries			71,717				
				GAS FIELD				
1.	Coons	McPherson	13-19- 1W	3,425	11- 6-40	Mississippian limestone	Core drill and subsurface	3 million cubic feet
	Total footage of oil and gas discoveries			75,142				

Ray and Penokee pools are situated on large blocks extensively core drilled by the Cities Service Oil Company. The discovery well was drilled on a farm-out by R. W. Shields after a previous test had been abandoned.

The McLouth pool in Jefferson County, northeastern Kansas, was discovered by McLaughlin *et al.* as a gas discovery of some value in 1939, but first oil was found in June, 1940. The discovery and only producer made 38 barrels of low-gravity oil from Mississippian beds. At the close of the year five gas wells and one dry hole had been drilled in the vicinity. Interest in the Kansas portion of the Forest City basin is barely kept alive by this discovery.

The Bedford and Stafford pools, as well as the less important Riley pool, are seismograph discoveries in Stafford County that have failed to develop as rapidly or as profitably as early results indicated. They produce from the Arbuckle dolomite, Viola limestone, and Lansing-Kansas City limestone, respectively.

In southeastern Russell County, a part of that county that has seen relatively little development, are the Mahoney, Lewis, Driscoll, Greenvale Northwest, and Davidson Northeast pools. These discoveries are relatively unimportant in themselves, but are indicative of undrilled reserves in the vicinity. All other pools are either extensions of old producing areas or are of little importance.

NEBRASKA

Drilling activity in Nebraska in 1940 increased to 61 completions compared with 7 in 1939. Activity was concentrated in the southeastern part of the state, principally in Richardson and Nemaha counties. The completion of 25 oil wells in the Fall City basin served as a spur to activity in adjacent parts of the state. Although few major companies entered into the play there was considerable interest by independent operators and local concerns. Many of these ventures were poorly organized and inadequately financed so that the play had a distinctly "boom" flavor.

WILDCATTING

Only one of the 29 wildcat tests completed in Nebraska in 1940 resulted in the discovery of a new pool. Four locations were abandoned. The footage of the 28 dry wildcats was 69,312 feet, and the total footage of all wells completed in the state was 145,600 feet.

The stratigraphic horizon reached by these wildcat wells is as follows,

Tertiary	1
Pierre	1
Dakota	1
Pennsylvanian	1
Hunton	15
Viola	3
Simpson	1
Arbuckle	3
Pre-Cambrian	3

It is evident from this table that many of the tests were incomplete insofar as being tests of the possibilities of the lower formations. However, inasmuch as no appreciable showings of oil or gas have been found to date in the Fall City basin, and since most of the wildcats were planned to test the Hunton limestone, operators were unwilling to drill to the lower horizons. The only discovery which can be considered as a forerunner of a new pool was made by the Indian Territory Illuminating Oil Company at their Schaible-Kuttler No. 1 in Sec. 29, T. 3 N., R. 16 E., which has been called the Schubert pool. This well found the top of a Devonian dolomite, which is generally termed the Hunton limestone, at 2,433 feet, and found a good showing of oil in a core at 2,435–2,441 feet. When the plug was drilled the well bailed at the rate of one barrel of 29.8° oil per hour, and after several acid treatments was completed in September, having an initial production of 325 barrels. Shortly after completion it began showing water. Before the end of the year dry holes were completed in Secs. 19 and 29 of the same township. Other near-by wells tend to indicate a pool of limited size. Early in 1941 a few other wells in the vicinity had found some oil but also considerable water so that the economic value of this discovery is questionable. The production of this pool to February 1, 1941, is estimated at 3,180 barrels.

The Uhri Oil Corporation's Ogle No. 2, in Sec. 9, T. 1 N., R. 14 E., attracted considerable attention in July after topping the Hunton limestone at 2,258 feet and finding saturation. When the plug was drilled it filled 800 feet with fluid in 36 hours, and after several acid treatments is reported to have pumped 380 barrels of fluid including 60 per cent water per day for 4½ days. It is estimated that about 1,000 barrels of oil was sold from this well during 1940. Early in 1941 further attempts are being made to shut off water in this well with apparently no success, so it is included among the 28 dry holes already mentioned. Three additional dry holes were completed during the year in the same township.

Most of the wildcats were located without benefit of geologic advice. Three of them including the discovery well of the Schubert pool were drilled on core drill features, one as the result of seismic work, and six on a basis of surface work of greater or lesser value.

Exploration in the western part of the state was limited to three completions, although two or three wells were drilled spasmodically throughout the year and were shut down at the end of the year. A summary of wildcat drilling in Nebraska is given in Table VI.

TABLE VI

WILDCAT COMPLETIONS IN NEBRASKA, 1940

County	*Location*	*Operator*	*Total Depth (Feet)*	*Horizon*
		PRODUCERS		
Richardson	29- 3-16E	Indian Terr. I. O.	2,452	Hunton
		DRY HOLES		
Pawnee	4- 1-10E	Blaser *et al.*	600	Pre-Cambrian
Richardson	22- 1-13E	Travis	3,141	Simpson
	6- 1-14E	Eckhart *et al.*	2,310	Hunton
	9- 1-14E	Uhri Oil	2,259	Hunton
	16- 1-14E	Powers and Stalder	2,341	Hunton
	22- 1-14E	Lewis *et al.*	2,406	Hunton
	3- 1-15E	Forest City Basin	2,605	Hunton
	5- 1-15E	H. Campbell *et al.*	3,398	Viola
	24- 1-15E	Pawnee Royalty	3,710	Arbuckle
	3- 2-15E	Indian Terr. I. O.	2,476	Hunton
	4- 2-16E	E. V. Jackson *et al.*	2,550	Hunton
	31- 2-16E	Midland Development	2,595	Hunton
	35- 2-16E	Carlock *et al.*	2,503	Hunton
Pawnee	31- 3-11E	Black Gold Oil	735	Pre-Cambrian
	14- 3-12E	Palensky *et al.*	733	Pre-Cambrian
Nemaha	16- 4-15E	Black Gold Oil	2,713	Hunton
	26- 4-15E	Clampitt *et al.*	2,732	Hunton
	19- 4-16E	E. V. Jackson *et al.*	2,587	Hunton
	35- 4-16E	Krone *et al.*	3,770	Arbuckle
	17- 5-13E	Schrock *et al.*	2,472	Hunton
	8- 5-14E	Garden *et al.*	3,110	Viola
	25- 5-14E	Black Gold Oil	1,357	Pennsylvanian
	15- 5-15E	Black Gold Oil	3,501	Viola
	34- 5-15E	Pulliam *et al.*	2,518	Hunton
	32- 5-15E	Nemaha Development	3,510	Arbuckle
Keith	21-14-37W	Calif-Nebraska	3,281	"Dakota"
Scotts Bluff	33-23-57W	Albert Wood *et al.*	1,209	Tertiary
	35-52-58W	Fairy Petroleum	2,100	Pierre
	Total footage of dry holes		69,312	
	Total footage of all wildcats		71,764	

DEVELOPMENT

Sufficient development work had occurred in and around the Fall City pool by the end of 1940 to indicate that no major field should be expected there. The completion of 25 oil wells in Secs. 17, 18, 20, and 29, producing from the Hunton limestone of Devonian age, gave little promise of repaying the industry for expenditures made in drilling and equipping the wells, and the leasing of hundreds of thousands of acres in near-by counties. Many of the wells did not show free oil when first drilled in, and only approached commercial production

after acid treatment. Moreover, the oil is of 30° gravity and contains between 8 and 12 per cent gasoline. Seven dry holes in the vicinity of the pool helped outline the producing area, and indicated a relatively sharp narrow structure was responsible for the accumulation. Tests drilled to the Viola limestone and Arbuckle dolomite failed to find commercial production, although encouraging showings of oil were found in the Viola limestone. The Fall City pool had produced an estimated 406,000 barrels to February 1, 1941. Nearly all wells were showing large proportions of water at that time.

MISSOURI

The wildcat play in Missouri in 1940 carried over from the previous year but at a slackened pace. At the end of the year there were a half dozen operations under way, several of which were about ready for abandonment. No commercial production was found, and very little indication that any would be found. Table VII lists the wildcat completions in Missouri during the year. These fall into two classes: those in the northwestern part of the state are in the Forest City basin; those in north-central and northeastern Missouri were drilled along the Lincoln fold described in the 60th biennial report (1939) of the Missouri Geological Survey.

TABLE VII

WILDCAT COMPLETIONS IN MISSOURI, 1940
(Exclusive of shallow tests in gas area)

County	*Location*	*Operator*	*Total Depth (Feet)*	*Horizon*
FOREST CITY BASIN				
Platte	16-53-34W	Roach and Dillingham	1,485	Hunton
Livingstone	15-56-23W	Chillicothe Syndicate	1,213	Arbuckle
DeKalb	11-57-31W	Moore *et al.*	1,500	Hunton
Buchanan	24-57-35W	Miller *et al.*	2,307	Arbuckle
DeKalb	30-58-31W	American Oil and Gas	2,261	Arbuckle
DeKalb	18-59-32W	Lawhon *et al.*	2,422	Arbuckle
Mercer	30-65-24W	Moore *et al.*	2,330	Arbuckle
	Total footage		13,518	
NORTHEASTERN MISSOURI				
Randolph	22-52-14W	Gallamore *et al.*	1,185	Arbuckle
Knox	18-61-12W	Oberthier and Reinke	935	Arbuckle
Adair	8-63-14W	Eddington *et al.*	1,247	Arbuckle
Adair	31-64-15W	Eddington *et al.*	1,163	Arbuckle
Schuyler	8-65-13W	Morrow and Rogers	1,400	Arbuckle
Schuyler	21-65-15W	T. E. Baldwin	1,505	Arbuckle
Schuyler	21-65-15W	T. E. Baldwin	1,024	Arbuckle
	Total footage		8,459	
	Total wildcat footage		21,977	

Results in both areas were equally unsuccessful. Several shallow gas wells and shallow dry holes were drilled in the gas area east and north of Kansas City, but these were of little economic value. At the end of the year most of the interest in the state was confined to the extreme northwestern part of the state directly east of Fall City, Nebraska.

SOUTH DAKOTA

The only completion in South Dakota in 1940 was the test of the South Dakota State Royalty Company, in Sec. 35, T. 18 N., R. 1 E., Harding County, which is believed to have been drilled to a total depth of 7,908 feet. Little information is available on this well. It was located on a surface anticline. Elsewhere in the state two or three stratigraphic tests were drilled, but information has not yet been released on them.

IOWA

In Union County the Phillips Petroleum Company abandoned their Creston No. 1, in Sec. 31, T. 71 N., R. 30 W., at a total depth of 2,860 feet in beds believed to be correlative with the Arbuckle dolomite. The section encountered in this well has been described elsewhere in the *Bulletin*.

In Fremont County, Oscar Gruber *et al.* drilled to 1,300 feet in a test located in Sec. 8, T. 67 N., R. 40 W. It apparently was bottomed in Pennsylvanian beds. Plans are being made to deepen this well during the current year.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1114-1124, 4 FIGS.

DEVELOPMENT IN EASTERN INTERIOR BASIN IN 1940[1]

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ABSTRACT

Oil production in the Eastern Interior basin reached a new high in 1940, about 55 per cent above 1939. Most of this increase was due to the drilling of wells in the Devonian limestone in the Salem and Centralia pools, Illinois. Thirty new oil pools were discovered in Illinois, five in southwestern Indiana, and one in western Kentucky. The Indiana discoveries were within about 10 miles of the Wabash River which is the Illinois-Indiana state boundary in this area. Twelve of the 30 new pools discovered in Illinois are in counties bordering the Wabash River. Geological conditions revealed by the new drilling are discussed.

INTRODUCTION

Drilling activity, both for exploration and for development of existing oil pools, reached a new peak in the Eastern Interior basin during 1940, when 4,680 wells were completed, 3,829 in Illinois, 450 in southwestern Indiana, and 401 in western Kentucky. Total oil production from the basin for the year was approximately 154,796,000 barrels as compared with approximately 99,922,000 barrels in 1939, an increase of 55 per cent.

The 1940 production of oil from the Eastern Interior basin was nearly equivalent to that of Oklahoma (155,952,000 barrels) and amounted to about 11.5 per cent of the United States total, of which nearly 11 per cent was from Illinois alone.

New oil pools discovered in 1940 in the Eastern Interior basin number 36, of which 30 are in Illinois, 5 are in Indiana and one is in Kentucky. Figure 1 is an index map showing the extent of the basin and the areas mapped in Figures 2 and 3.

For further statistical information the reader is referred to the forthcoming annual *Transactions* of the A.I.M.E. Petroleum Division.

The present paper is an attempt to summarize in a preliminary way some of the geologic data revealed by the new drilling.

EXPLORATORY DRILLING

During 1940, 523 wells classified as wildcats were drilled in Illinois, of which 48 or 9 per cent were successful in obtaining production, 30 discovering new pools, and 18 discovering extensions to known pools. Wildcat wells were drilled in 64 of the 102 counties of the state. They

[1] Read before the Association at Houston, April 4, 1941. Manuscript received, March 14, 1941. Published with the permission of the chief, Illinois State Geological Survey.

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ranged in location from DeKalb County on the north to Massac County on Ohio River on the south and from Adams County on Mississippi River on the west to the border counties on the Indiana line on the east. More than 90 per cent of the wildcat wells were located in the

FIG 1.—Index map of Eastern Interior basin and areas shown in Figures 2 and 3.

southern half of the state; 235 or 45 per cent were in the 15 counties[3] located in the deep part of the basin, whereas 189 or 36 per cent were located in 15[4] of the 16 counties immediately adjacent. It is of interest to note that 22 of the 30 new pools and 12 of the 18 extensions were in the 15 deep-basin counties, the remaining 8 new pools and 6 extensions being confined to 7 of the 16 adjacent counties.

[3] Clay, Cumberland, Edwards, Effingham, Fayette, Franklin, Hamilton, Jasper, Jefferson, Marion, Richland, Shelby, Wabash, Wayne, White.

[4] Bond, Christian, Clark, Clinton, Coles, Crawford, Gallatin, Jackson, Lawrence, Macon, Montgomery, Perry, Saline, Washington, Williamson.

Clinton County, one of the counties bordering the west side of the deep-basin area, had the largest number of wildcats—46—but these discovered only one new pool which is of minor importance and one extension. White County, in the deep-basin area, had the second largest number of wildcats—39—and the largest number of new discoveries—6 new pools and 6 extensions.

GEOLOGIC AGE OF PRODUCING FORMATIONS

In spite of the rapid development of Devonian limestone production during the first half of 1940, the Mississippian system continues to be by far the most important source of oil in the Eastern Interior basin. It is estimated that the Devonian limestone produced about 26 per cent of Illinois' production in 1940. The total from the Pennsylvanian and Ordovician systems was probably less than 2 per cent so that 72 per cent of the total was from the Mississippian.

No new areas of Devonian limestone production were discovered in 1940 and the proved areas in the five Devonian pools in western Illinois were almost completely drilled up during the first half of the year. Planimeter measurements indicate the following productive areas in the Devonian as of December 31, 1940.

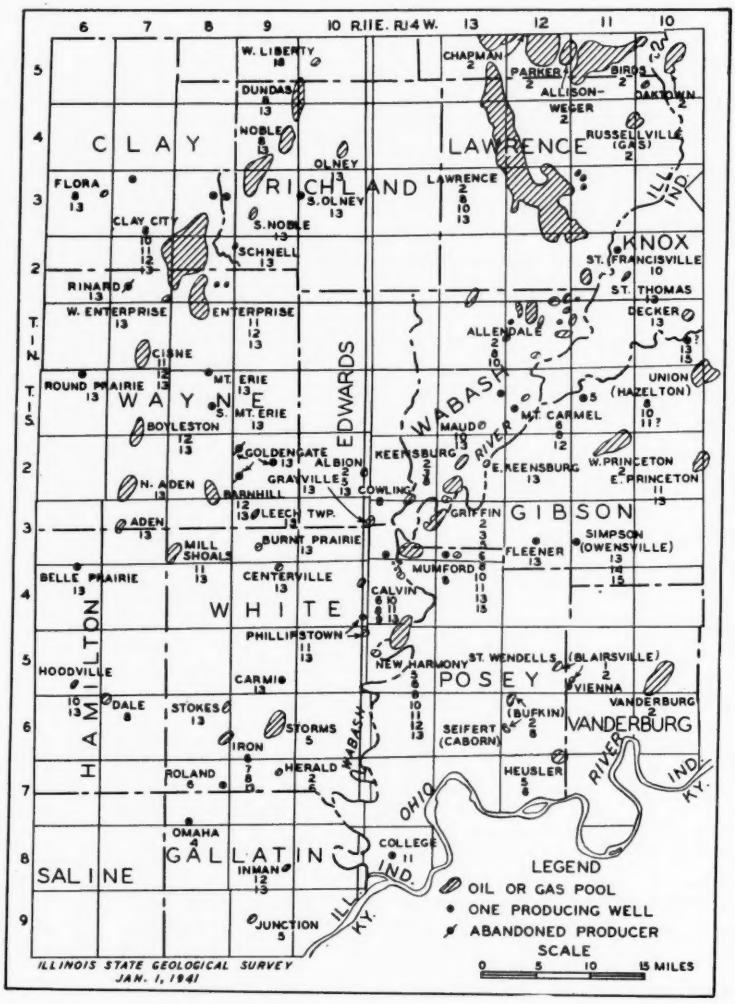
Pools	*Acres*
Sandoval	380
Salem	5,000
Tonti	21
Centralia	2,200
Bartelso	230
Total	7,831

It is of interest to note that the actual productive acreage found for the Devonian in the Salem pool is identical with that estimated a year ago.[5]

Only one of the 48 discovery wells in Illinois found production in the Devonian; this was an extension of the Bartelso pool. The McClosky oölitic limestone (in the Fredonia member of the Ste. Genevieve formation, lower Mississippian series) was the producing formation in 27 of the 48 discovery wells, 16 new pools and 11 extensions. Most of these new McClosky pools are in counties bordering Wabash River. One new pool, the Inman pool in Gallatin County, produces from the Rosiclare sandstone, which is also in the Ste. Genevieve formation, just above the Fredonia.

Various Chester sandstones produced oil in 10 new pools and 4 extensions, that is, the Aux Vases (basal Chester), 2 extensions; Bethel

[5] Alfred H. Bell, "Developments in the Eastern Interior Basin, 1939 and First Quarter of 1940," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 6 (June, 1940), p. 967.



Key to Producing Strata

	Map No.
Pennsylvanian system	
McLeansboro group	1
Tradewater group	2
Caseyville group	2
Mississippian system	
Chester series	
Clore formation	3
Palestine formation	4
Waltersburg formation	5
Tar Springs formation	6
Hardinsburg formation	7
Cypress formation	8
Paint Creek formation	9
Bethel formation	10
Aux Vases formation	11
Iowa series	
Rosiclare member	12
Fredonia member	13
St. Louis formation	14
Salem formation	15

FIG. 2.—Lower Wabash River area, Illinois and Indiana, showing oil and gas pools and producing formations in each pool indicated by numbers under pool name (see table for key). Information on Indiana pools furnished by G. F. Fix, State gas supervisor, Indianapolis, J. B. Robertson, Evansville, Indiana, P. S. McClure, Shell Oil Company, Evansville, and S. G. Elder, Sun Oil Company, Evansville.

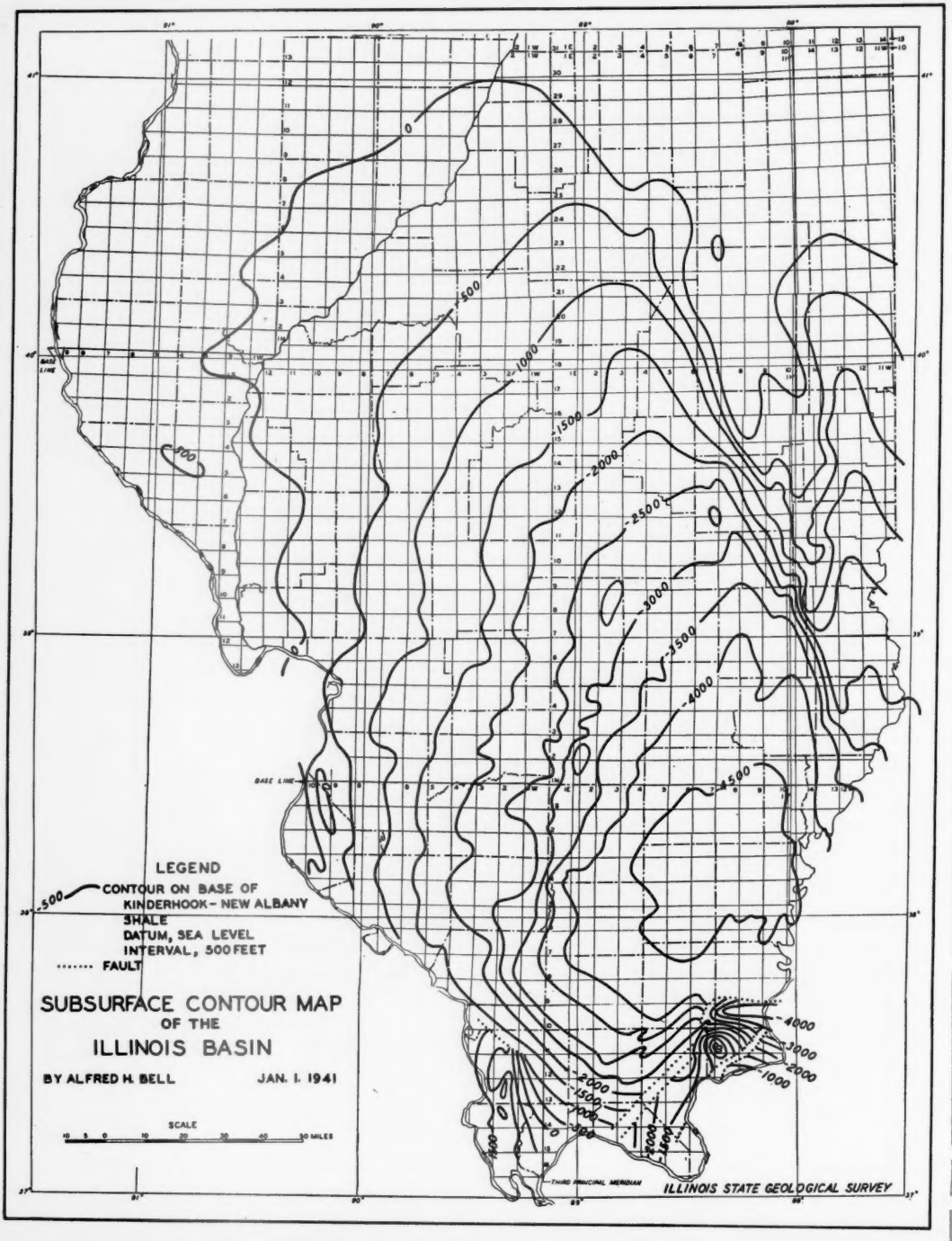

LEGEND
-500 CONTOUR ON BASE OF KINDERHOOK - NEW ALBANY SHALE
DATUM, SEA LEVEL
INTERVAL, 500 FEET
..... FAULT
SUBSURFACE CONTOUR MAP
OF THE
ILLINOIS BASIN
BY ALFRED H. BELL
JAN. 1. 1941
SCALE
10 5 0 10 20 30 40 50 MILES
BASE LINE
THIRD PRINCIPAL MERIDIAN
ILLINOIS STATE GEOLOGICAL SURVEY

FIG. 3

sandstone, 5 new pools, all west of the deep-basin area; Cypress sandstone, 2 new pools and 1 extension; Hardinsburg, 1 new pool; Tar Springs, 1 new pool and 1 extension; Palestine, 1 new pool. Pennsylvanian sandstone produced oil in 3 new pools and 1 extension.

A multiplicity of producing formations is especially noteworthy in the region bordering Wabash River, both in Illinois and in Indiana. This is illustrated in Figure 2. In this region the distribution of the productive areas appears to be controlled by sand conditions to a greater degree than by structure. Much work remains to be done to interpret the geologic history and occurrence of oil in this area.

DEVONIAN STRUCTURE MAP

In order to provide the latest interpretation of regional structure for Illinois for the tectonic map of the United States, the writer was called on to revise the subsurface contour map of the Illinois basin on the base of the Kinderhook-New Albany shale as of January 1, 1941 (Figure 3). Some noteworthy differences between this map and that presented a year ago are: (1) three areas of closure, (a) in northern Champaign County, (b) southwestern Coles County (Mattoon area), and (c) the Louden pool area, Fayette County; (2) many more bends in the southern part of the −4,500-foot contour; and (3) much greater complication in extreme southern Illinois where the contours have been revised in accordance with the findings of J. M. Weller.[6]

RESULTS OF DEEP TESTING IN 1940

Oil production was discovered in the Kimmswick ("Trenton") limestone of Ordovician age in the Centralia and Salem pools in 1940, but only small initial productions were obtained in the discovery wells —100 and 130 barrels, respectively. A second "Trenton" well in the Centralia pool had an initial production of 74 barrels. By the end of the year production of both "Trenton" wells in the Centralia pool had declined greatly.

The small initial production of the Trenton discovery well in the Salem pool is not a good index to the formation's capacity to produce because at first trouble was experienced in pumping the well at the considerable depth of 4,500 feet. Production was later brought up to about 200 barrels per day. A number of Trenton wells have been brought in in the Salem pool since January 1, 1941, but a description of them is outside the scope of this article.

The results of the few tests drilled to the St. Peter sandstone are

[6] J. M. Weller, "Geology and Oil Possibilities of Extreme Southern Illinois," *Illinois Geol. Survey Rept. Inv. 71* (1941).

not encouraging. The deepest of these is The Pure Oil Company's Billington well No. 3 in the Cisne pool, Wayne County, in the deep-basin area (Fig. 4, map No. 19). Total depth was 7,207 feet and the top of

FIG. 4.—Map showing important deep tests in Illinois completed or nearly completed in 1940.

the St. Peter was at 7,114 feet. The St. Peter formation here is fine-grained compact well cemented sandstone, with but slight porosity. In the Carter Oil Company's Seaman well No. 1, near Mattoon (Fig. 4, map No. 6; total depth 4,908 feet, top of St. Peter 4,689 feet), the St. Peter is medium-grained friable porous sandstone like that found in water wells in northern Illinois. The Glenwood formation, consisting of fine-grained sandstone beds, lying just above the St. Peter, had a slight showing of oil.

Data on important deep tests completed in Illinois in 1940 are given in Table I and Figure 4.

SOUTHWESTERN INDIANA

The following information on developments in southwestern Indiana was furnished by G. F. Fix, State gas supervisor, Indianapolis, Indiana.

TABLE I

IMPORTANT DEEP TESTS IN ILLINOIS IN 1940

(See Figure 4 for locations)

Map No.	*County*	*Pool*	*Location*	*Company*	*Farm No.*	*Depth, Feet*	*Deepest Formation*	*Top Feet*	*Initial Production (Bbls.)*	*Date Completed*
1	Clinton	Centralia	NW NE NE 13- 1N- 1W	Borton	Storer 1	4,120 PB 4,070	"Trenton"	4,012	100	12- 3-40
2	Clinton	Carlyle	SE NE SE 3- 2N- 3W	Schwarz	Schlafly 1	4,120	St. Peter	4,106	Dry	1- 7-41
3	Clinton	Centralia	SW NE SE 12- 1N- 1W	Ames	Hicks 2	4,068	"Trenton"	4,018	74	7- 2-40
4	Clinton	(Wildcat)	NE NE SW 17- 3N- 4W	Tatum	Schrage 1	3,549	St. Peter	3,516	Dry	7-16-40
5	Clinton	(Wildcat)	SW SE SE 33- 2N- 4W	Trumbell	Peters 1	3,305	"Trenton"	3,210	Dry	7-23-40
6	Coles	Mattoon	NW NE SW 35-12N- 7E	Carter	Seaman 1	4,908	St. Peter	4,689	Dry	5-14-40
7	Edwards	Albion	NW NE SW 19- 2S -11E	Superior Oil	Green 1	5,185	Devonian	4,907	Dry	7- 9-40
8	Edwards	(Wildcat)	SE SE NE 36- 2S -10E	Superior Oil	Scott 1	5,196	Devonian	4,951	Dry	8-27-40
9	Jackson	(Wildcat)	SW SE SE 35- 8S - 5W	Trumbell	Bennett 1	2,950	"Trenton"	2,755	Dry	9-24-40
10	Jackson	(Wildcat)	SW SW SW 32-10S - 3W	Manellin	Baysinger 1	2,294	St. Peter	2,288	Dry	9-20-40
11	Jackson	(Wildcat)	SE SE NE 9- 8S - 3W	Magnolia Pet.	Smith 1	3,893	"Trenton"	3,705	Dry	12-31-40
12	Jasper	West Liberty	C E ½ NW NW 16- 5N-10E	Pure Oil	Redman 1	4,584	Devonian	4,316	Dry	7- 9-40
13	Marion	Sandoval	SW SE SW 4- 2N- 1E	Martin	Robinson 1	5,023	St. Peter	4,978	Dry	1-14-41
14	Marion	Salem	SW NE SW 29- 2N- 2E	P. Rossi	Brooks 8	4,618	"Trenton"	4,505	130	2- 4-41
15	Marion	Fairman	C E ½ NE NW 18- 3N- 1E	Shell Oil	Ververs 6-C	4,100	"Trenton"	3,927	Dry	10-29-40
16	Marion	Patoka	NE NE SW 28- 4N- 1E	Jones *et al.*	Majonnier 2	2,956	Devonian	2,886	Dry	3- 5-40
17	Monroe	(Wildcat)	SE SW SE 19- 1S -10W	Hoffer	Boyer 2	2,270	Cambrian	2,200	Dry	8-13-40
18	Randolph	(Wildcat)	SW NW SW 16- 7S - 7W	Anderson	Cassoutt 1	1,698	"Trenton"	1,555	Dry	8-13-40
19	Wayne	Cisne	C E ½ SE NE 27- 1N- 7E	Pure Oil	Billington 3	7,207	St. Peter	7,114	Dry	5-14-40
20	Wayne	N. Aden	SW NW SW 33- 2S - 7E	Rockhill	Twist A-7	5,393	Devonian	5,135	Dry	8- 6-40
21	White	Phillipstown	C W ½ NW NW 31- 4S -11E	Phillips Pet.	Garr 1	5,349	Devonian	4,885	Dry	5-14-40
22	White	(Wildcat)	NW SW NE 13- 7S - 8E	Kingwood	Martin	5,225	Devonian	4,888	Dry	7- 2-40

Oil and gas prospecting and drilling reached a higher peak in Indiana during 1940 than for any like period in the past decade. The amount of wildcat activity was not much greater than for 1939, however, because most of the increase was due to inside drilling in already proved areas, for example, the Griffin and Rockport fields. Only one new field of commercial importance was discovered during the year. This was the College pool, located in southwestern Posey County. Production is found in the Aux Vases sandstone at depths of approximately 2,600 feet, although some saturation has been found in higher Chester sandstones. Other areas discovered during the year include the following. (1) Bufkin, in central Posey County, produces chiefly from lower Pennsylvanian sands, including the basal Pennsylvanian Mansfield sandstone, and from the Cypress sandstone of Chester age. A total of 16 oil and gas wells had been completed in this field at the end of the year. (2) The St. Thomas field, in southwestern Knox County, primarily in Secs. 24 and 25, T. 2 N., R. 11 W., was discovered late in the summer. Production is from the McClosky formation of the Ste. Genevieve limestone at depths of approximately 1,800 feet. Initial production from wells in this field varied from 100 to 300 barrels a day, but the saturation is very spotty, and at the end of the year more dry holes had been completed than oil wells. Five oil wells were pumping and flowing at the end of the year. There was also some new activity in the old Gentryville pool in northern Spencer County, with one or two small wells completed.

The Griffin field received the bulk of drilling during the year, with 173 completions, of which 10 were dry holes. This makes a total of 253 producing wells in the field which was considerably extended during the year. The New Harmony field, located on Ribeyre Island in western Posey County, had 5 completed oil wells for a total of 24 producers. The Rockport gas field, in southern Spencer County, had 50 completions, of which 27 were gas, 9 were oil and 14 were dry holes. The 9 completed oil wells in this field represent the first oil production from Rockport, no commercial oil wells having been completed previous to 1940. Most of the older Indiana fields had one or more completions each, for small oil and gas wells.

The total number of completions in Indiana for 1940 was 521, of which about 450 were in the southwestern part of the state, or that part included in the Eastern Interior coal basin. This number is considerably greater than the 377 completed in the state in 1939. Of the total number of completions, 248 were oil wells, 77 were gas wells, and 196 were dry.

Oil production in Indiana in 1940 was slightly more than 5 million

barrels, as compared with about 1¾ million barrels for the previous year. Gas production also was increased considerably, due to the flush production from the Rockport field. Pipe-line proration, which has been effective in reducing the output from older fields for the past 3 years, was removed late in 1940. This proration has varied considerably in allowable, but never was more than ⅔ the daily potential of the well.

Although southwestern Indiana is expected to receive at least as great and possibly greater development during the coming year, the scene of active leasing and exploration was shifting to the north and northwestern parts of the state at the end of the year. Several seismograph, magnetometer, and soil-analysis crews are busy in this area, as well as geologists working surface and subsurface geology. Many major companies as well as a large number of independent companies are interested and many large blocks of leases have been assembled, although little actual drilling has taken place.

WESTERN KENTUCKY

The following information on developments in western Kentucky was furnished by D. J. Jones, State geologist, Lexington, Kentucky.

Oil and gas production maintained normal levels throughout the year. Altogether, 175 oil wells, 10 gas wells, and 216 dry holes were recorded.

Production for the year 1940 was 5,178,814 barrels as compared with 5,518,449 barrels for 1939. That part of the state west of the axis of the Cincinnati arch produced 3,164,673 barrels.

The Chester sands have accounted for a greater part of the new production.

A new pool has been developed near Handyville in southwestern Daviess County.

Several old producers in the Utica and Grindstone Hill areas have been deepened to the McClosky with encouraging results.

The sands of the Chester group in much of the area of the Western coal basin are found at a very shallow depth. Production in general ranges from 250 to 1,500 feet. The small company, and particularly the individual operator, can prospect and develop production at a low cost.

Completions were reported from 22 counties, testing beds from Pennsylvanian to Lower Ordovician. Several blocks are under lease in the western part of the state (Jackson Purchase). Ballard, McCracken, Carlisle, and Graves counties are in line to receive Ordovician tests.

The area west of the Cincinnati arch and east of the Western coal basin has reported the usual drilling activity. Most of these were Devonian tests in the area of the Mississippian. A few shallow Ordovician tests resulting in a very small amount of production were reported from Cumberland County.

Throughout Kentucky there seems to be considerable interest in the possibility of production from the St. Peter sand and Knox dolomite. A Knox completion in the Gainesville pool of Allen County was dry. This was the deepest stratigraphic test during 1940 for western Kentucky. Scattered tests to these horizons in western Kentucky have not furnished conclusive information. Some of them were not drilled on favorable surface structure and with few exceptions no consideration was given to the probability of favorable subsurface conditions. There are porous zones in the Knox that under proper conditions of structure should be reservoirs for oil and gas.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1125–1134, 2 FIGS.

OIL AND GAS DEVELOPMENTS IN MICHIGAN IN 1940[1]

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ABSTRACT

The southwestern part of Michigan was the center of oil and gas activity for the state during the greater part of 1940 with activity increasing in the "Basin" area as the year closed.

The discovery and partial development of three new shallow "Stray" sand (Mississippian) gas areas and important extensions elsewhere have increased materially the gas reserves of the state. Gas production during 1940 was approximately 40 per cent greater than in the previous year.

Despite numerous oil discoveries and extensions to proved areas, the additions to known oil reserves were of no great consequence. Oil production for 1940 was actually 16 per cent less than in 1939 but a general strengthening in price partially offset this decline.

Several geophysical parties were reported operating in the Southern Peninsula, but core testing seemed to be the favored exploratory method.

The search for new deep producing zones has received some encouragement. In the "Basin" substantial gas showings were encountered in the basal Salina (Silurian). In southwestern Michigan showings of oil were reported at the approximate horizon of the St. Peter sandstone.

INTRODUCTION

This paper reviews briefly the developments in the petroleum industry in Michigan during 1940. For this discussion the state has been divided into two areas, namely, the "Basin" (central Michigan) and the southwestern Michigan districts. No attempt is made to discuss other than the more important discoveries and extensions. The older fields have been discussed in previous papers in the *Bulletin*.

During 1940 greater emphasis has been placed on natural gas rather than on oil discoveries due to the fact that the natural gas reserves were materially increased whereas the oil reserves showed a decline.

The natural-gas industry in the state made greater progress than in any year since 1935 with the discovery and partial development of three new fields in the "Basin." Approximately 150 miles of new gas transmission lines were constructed or under construction at the end of the year.

The discovery of gas near the base of the Salina (Silurian) salt section by the Gulf Oil Company's Bateson No. 1, five miles northwest of Bay City in Bay County, focused the interest of the industry on the "Basin." This well with the substantial showings made thus far supports the belief held over the past several years that the Basin district

[1] Read by title before the Association at Houston, April 4, 1941. Manuscript received, March 20, 1941.

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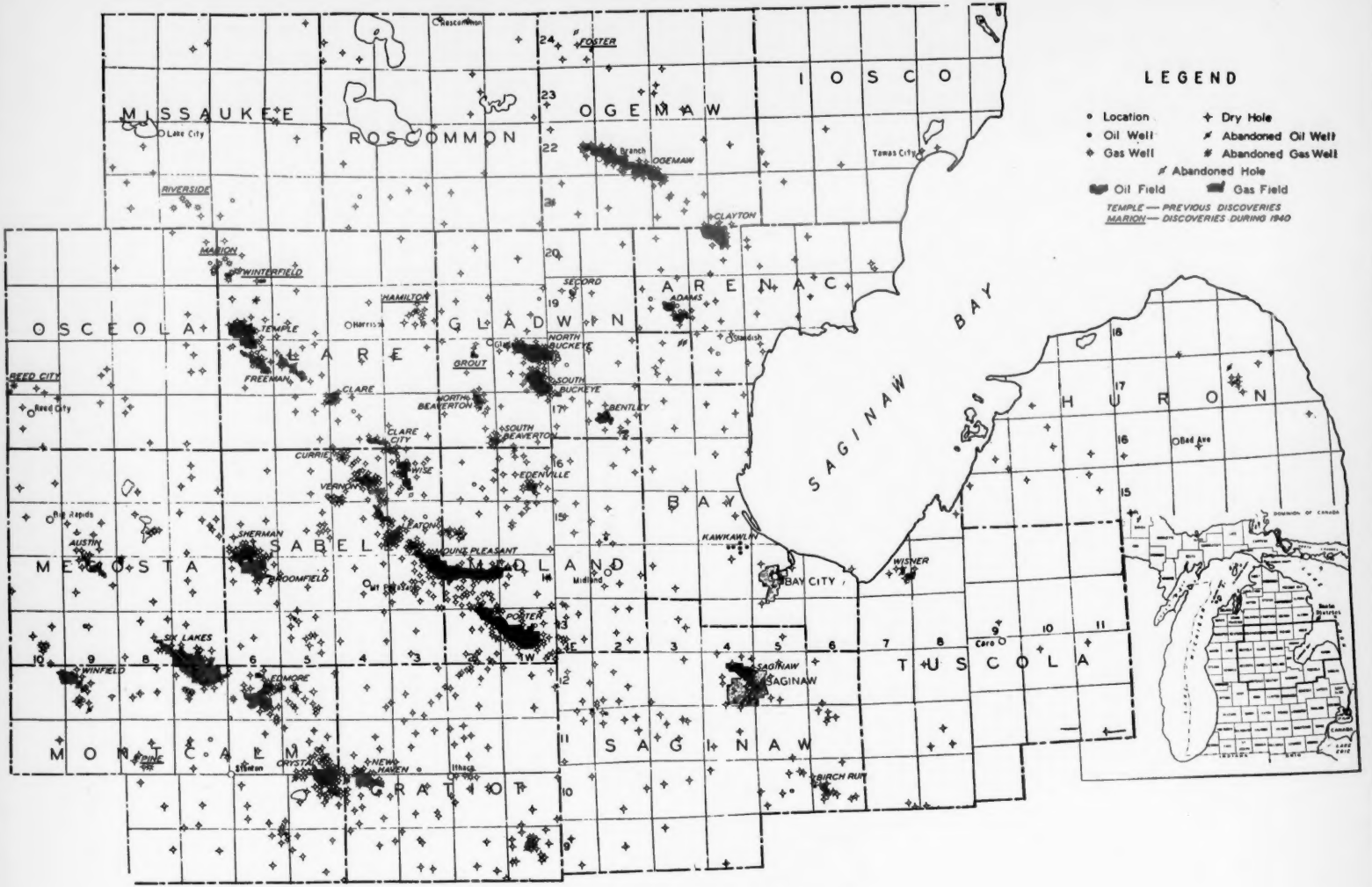

FIG. 1.—Map showing Basin district of Michigan.

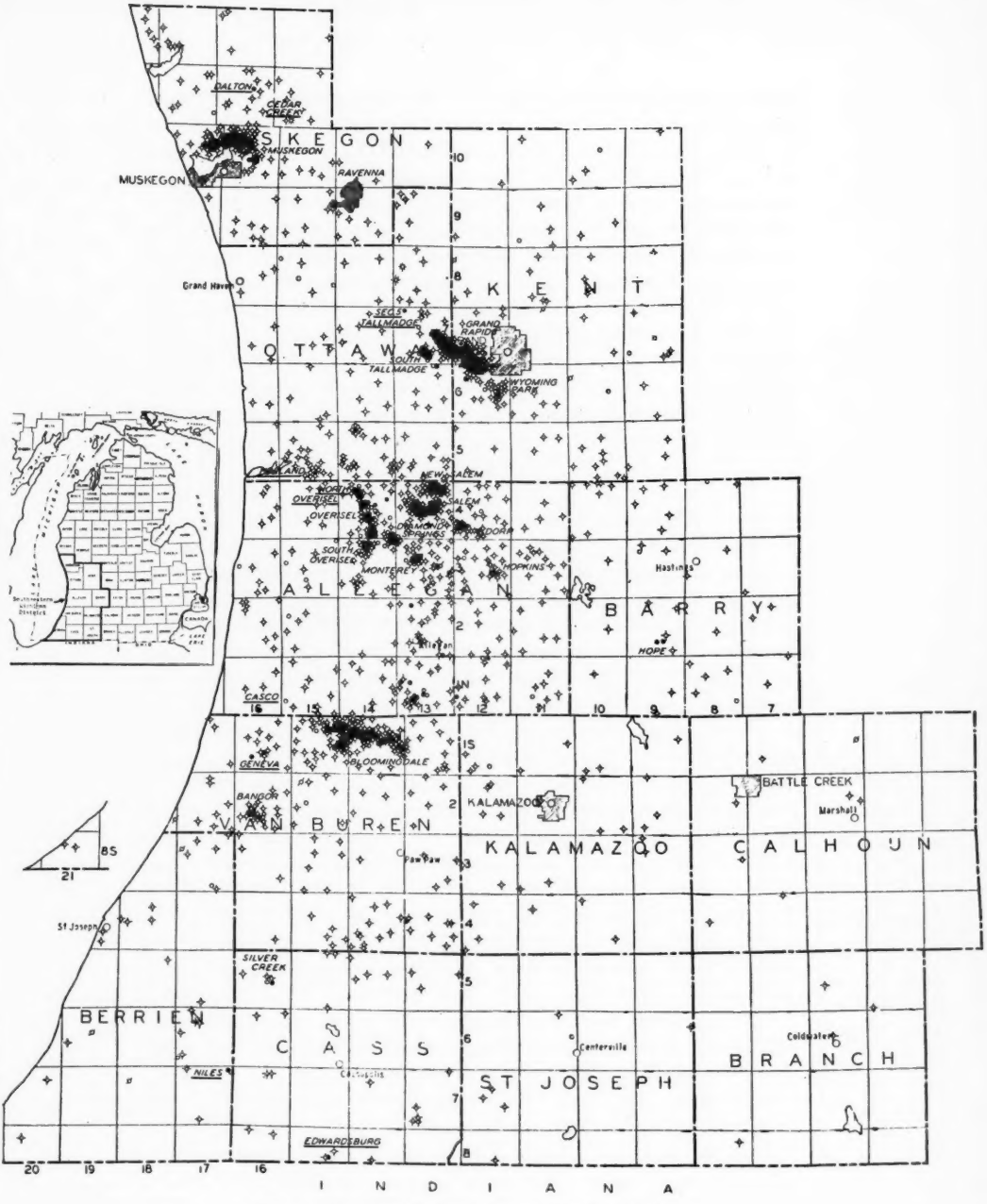

FIG. 2.—Map showing Southwestern district of Michigan.

FIG. 1.—Map showing Basin district of Michigan.

has good possibilities for production from deeper formations not yet explored.

Well completions during 1940 totaled 1,181 as compared with 1,479 in 1939. This reduction reflects not so much a lessening of interest in the state as the failure of new discoveries to develop into fields. There were 29 oil and gas discoveries and major extensions during the year, about equally divided between the "Basin" and southwestern Michigan. Of the discoveries, six were extensions of older pools, ten at the end of the year were still one-well pools, three had been plugged, and ten offered some possibilities for further development. Exploration work was carried on at about the same pace as in 1939. Approximately two-thirds of the core tests for locating structure were made in the southwestern Michigan district and the remaining one-third in the "Basin."

NATURAL GAS

In the Basin district discovery of new fields and development of old gas areas went forward. Clare, Missaukee, Montcalm, Gratiot, Arenac, and Osceola counties (Fig. 1) had 56 new wells. Casinghead gas production from the Temple field in Clare County and the Grand Rapids field in Kent and Ottawa counties (Fig. 2) showed a marked increase due to pipeline connections not available in 1939. Total gas production for the state was 40 per cent greater than in the preceding year.

The Marion field in Clare and Osceola counties, about 6 miles north of the Temple oil field, was discovered, June 25, 1940, by Taggart Brothers Company's Woodin and Baughan No. 30 (center, SW. $\frac{1}{4}$ of Sec. 19, T. 20 N., R. 6 W.) which had a daily open flow of 6,750,000 cubic feet from the "Michigan Stray" at a depth of 1,419 feet. By the end of the year, 14 wells had been drilled. The field as now developed includes parts of Secs. 19, 20, 28, 29, 30, 31, and 32 of T. 20 N., R. 6 W.; Secs. 25 and 36, T. 20 N., R. 7 W., and Sec. 1, T. 19 N., R. 7 W.

The Lincoln pool in Clare County, T. 18 N., R. 5 W., was expanded southeastward into Secs. 27 and 28 with nine gas wells drilled during the year.

The Riverside field in Missaukee County, T. 21 N., R. 7 W., was discovered, June 19, 1940, by Taggart Brothers Company's Quist No. 29 (center, NW. $\frac{1}{4}$ of Sec. 22). The well had a daily open flow of 7,300,000 cubic feet from the "Michigan Stray" at a depth of 1,415 feet with a reported rock pressure of 640 pounds per square inch. Three additional producing wells in the following locations were drilled: center, SE. $\frac{1}{4}$ of Sec. 16; center, SE. $\frac{1}{4}$ of Sec. 20; and center, SW. $\frac{1}{4}$ of Sec. 23.

Although the wells were rather widely separated and the producing area not definitely outlined, it is evident that the field when developed will substantially add to the gas reserve of the state. This district offers considerable possibilities for development during 1941.

The Richland-Home gas area was about as active in 1940 as in the preceding year. In the Edmore pool, Home Township (T. 12 N., R. 6 W.) nine wells were drilled to extend the pool to include parts of Secs. 12, 13, 14, 15, 21, and 26. On February 3, E. C. Dailey's Church No. 1 (Sec. 17, T. 12 N., R. 5 W., Richland Township) was completed at a total depth of 1,215 feet in the "Michigan Stray" with an initial daily open flow of 6,230,000 cubic feet. Two other gas wells were completed in Secs. 8 and 17. It is possible that future drilling will prove this pool to be an eastward extension of the Edmore field.

The Reed City gas area was discovered, November 15, 1940, by Taggart Brothers Company's Cornell-Lomp No. 55 (Sec. 30, T. 18 N., R. 10 W.) which had an initial daily open flow of 7,500,000 cubic feet from the "Michigan Stray" at a depth of 1,245½ feet. A second well also in section 30 was drilled with a reported daily open flow of 12 million cubic feet. This district is expected to be developed further during 1941.

Michigan Consolidated Gas Corporation, which markets gas in the Grand Rapids and Muskegon area, purchased all the gas wells and virtually all of the landowners' royalty rights in the Austin field (northern part of T. 14 N., R. 9 W.), Mecosta County. The Austin field will temporarily be used as a storage reservoir for gas produced during the summer from the Freeman and Lincoln pools. During the winter, gas will be produced from the reservoir for consumption in Muskegon and smaller communities adjacent to the existing line from Austin field to Muskegon.

OIL

In the search for and development of oil, southwestern Michigan dominated the play for the greater part of the year. Increased activity in the "Basin" area was evident as the year closed. Oil production (Table I) dropped 16 per cent from 1939 despite twenty discoveries and major extensions. Oil wells for the year totaled 557. Comparative distribution of wells between the two major areas is shown in Table II.

SOUTHWESTERN MICHIGAN

The Grand Rapids field (Walker-Wyoming-Tallmadge townships in Kent and Ottawa counties) was the most active in the state with 170 producing wells completed. The field was expanded to include

TABLE I

MICHIGAN PRODUCTION BY FIELDS*

Field	1940 Production (in Barrels)	Total Production (in Barrels)	Field	1940 Production (in Barrels)	Total Production (in Barrels)
Saginaw	23,668	1,351,056	Pine	5,514	23,489
Muskegon	38,570	6,656,341	Monterey	44,278	322,411
Mount Pleasant	408,782	21,136,863	Dorr	31,161	241,080
Leaton	137,058	2,750,832	Clare City	3,875	11,286
Vernon	154,067	4,126,444	Wisner	700	15,321
Porter	1,234,469	30,538,079	Diamond Springs	79,548	655,418
Yost	509,944	6,110,574	Temple	4,442,614	10,217,040
Ogemaw	492,917	4,150,913	Bloomingdale	1,001,980	4,886,792
Edmore	18,470	404,327	Overisel	83,056	493,103
Birch Run	9,895	180,610	Wise	848,166	1,125,811
Sherman	461,799	3,601,780	Mill Lake	55,507	286,784
Beaverton	35,012	600,495	Columbia	487,483	1,701,821
Mount Haley	1,610	28,845	Walker	4,217,424	7,039,504
Crystal	83,054	7,071,814	New Salem	1,051,859	2,368,489
Geneva (Midland Co.)	3,091	60,996	Hopkins	33,902	92,936
Larkin	71	6,940	Bangor	94,450	172,122
Deerfield	108,585	152,150	Tallmadge	34,775	37,370
South Buckeye	181,014	3,559,293	Zeeland	2,322	8,617
South Beaverton	62,480	110,779	Wyoming Park	54,071	66,797
Currie	7,312	143,310	South Overisel	662,566	699,613
Clayton	410,161	3,207,648	North Overisel	278,230	278,230
Winfield	2,035	10,988	Holland	8,373	8,373
North Buckeye	823,768	13,771,713	Hope	1,737	1,737
Salem	404,411	2,492,019	Dalton	692	692
Fremont	170	1,601	Grout	3,531	3,531
Adams	313,011	433,386	Geneva (Van Buren)	3,450	3,450
Bentley	125,041	537,770	Hamilton	9,512	9,512
Secord	1,357	12,024	Niles	228	228
Lakefield	1,209	3,730	Casco	309	309
Trowbridge	19,098	31,230	Winterfield	4,441	4,441
Edenville	109,836	1,029,266	Reed City	1,272	1,272
Kawkawlin	15,850	42,105	Sec. 5 Tallmadge	204	204
Total cumulative production from Michigan since 1925				145,234,569 barrels	

* Fields which had no production in 1940 are not listed.
Fields are listed approximately in the order of discovery.

parts of Secs. 14, 15, 16, 23, 24, 25, and 26 of Tallmadge Township (T. 7 N., R. 13 W.). Production in the field reached its peak in January, 1940, with 566,665 barrels and declined steadily to 162,940 barrels in December. At the end of the year recovery had been approximately 1,500 barrels per acre.

TABLE II

SUMMARY OF OPERATIONS, BY DISTRICTS, IN MICHIGAN DURING 1940

Area	Permits Issued	Wells Completed	Oil Wells	Initial Production Oil (Bbls.)	Gas Wells	Initial Production, Gas (1,000 Cubic Feet)	Dry Holes	Actual Production, 1940	
								Oil (Barrels)	Gas (1,000 Cubic Feet)
Southwestern Michigan	716	790	406	78,841	2	579	382	8,691,188	1,806,928
"Basin"	306	299	132	47,734	56	315,413	111	10,953,259	12,319,436
All other parts of State	98	92	19	1,678	1	225	72	108,656	—
Total	1,120	1,181	557	128,253	59	316,217	565	19,753,103	14,126,364

The South Tallmadge pool was opened by the Smith Petroleum Company, in July, 1939, with a 14-barrel well in Sec. 27, T. 7 N., R. 13 W., but no further drilling took place until 1940. Wells of small potential kept development at a slow pace until December when a well was completed in Section 34 which flowed upwards of 1,000 barrels per day. During the year the field was expanded to include portions of Sections 23, 24, and 26. Another producing area was found southeastward on the same structure in Section 2 of Georgetown Township (T. 6 N., R. 13 W.). Five wells were drilled in this pool. Indications are that this structure, which parallels the Grand Rapids structure, will be further developed in 1941.

Considerable activity was seen in the Overisel producing area (T. 4 N., R. 14 W.) in Allegan County. The South Overisel pool was extended to include most of Section 34. In March, Lang and Lewis Incorporated's Nevenzel No. 1 (center, E. ½, NW. ¼, SW. ¼ of Sec. 3, T. 3 N., R. 14 W.) extended the field approximately one mile south. In the South Overisel field, 66 producing wells were drilled in 1940.

In June, interest was focused on the northern part of the Overisel area when H. C. Nelson's Peters No. 1 (SE. ¼, SE. ¼, NE. ¼ of Sec. 8, T. 4 N., R. 14 W.) was completed with an initial production of 400 barrels per day. In the North Overisel pool development was rapid and by the end of the year, 40 producing wells were completed in Sections 9, 15, 16, and 21.

On December 19, 1940, W. L. McClanahan's Campagner No. 1 (SW. ¼, SE. ¼, SE. ¼ of Sec. 1, T. 4 N., R. 14 W.) caused renewed interest in the area when it was completed with an initial production of 139 barrels per day.

BASIN DISTRICT

The Adams field was discovered in July, 1937, by E. H. Linabury's McTaggart No. 1 (SE. ¼, NE. ¼, SW. ¼ of Sec. 26, T. 19 N. R. 3 E.) which made 50 barrels of oil per day from the Traverse formation at a depth of 2,044 feet. Subsequent to discovery, production was found in the Dundee formation approximately 800 feet below the Traverse, but development was slow due to small potentials and to interest in other fields. The Dundee "pay" is 35–50 feet in the formation and averages 6 feet in thickness. The "pay" is limestone with low porosity. Up to July, 1940, 16 wells had produced 143,739 barrels and the field was averaging 100–180 barrels per day as of July 1.

In July, 1940, Don Rayburn's Yenior No. 1 (N. ½, SW. ¼, NE. ¼ of Sec. 22) extended the field one mile northwest. This well was completed in the Dundee with an initial production of 1,981 barrels. Interest was revived in the area and by the end of the year, 28 wells were

producing. At the close of 1940, the daily average for the field was 2,400 barrels of oil and total accumulative production was 433,386 barrels. The field is on a northwestward-plunging nose and has at present about 40 feet of closure. Adams is a water-drive field with a very low gas-oil ratio. Production is from limestone of varying porosity. The "pay," which averages 4 feet in thickness, is in zones where the limestone has been dolomitized. In this extension, which is approximately 30 feet lower than in the original pool and partially cut off from it by a low saddle, there are two pay zones. The upper "pay" is from 9 feet below the top of the Dundee and the lower "pay" from 100 to 117 feet in the formation. Some wells miss the upper "pay" entirely, but are productive in the lower "pay."

Two discoveries in Winterfield Township (T. 20 N., R. 6 W.), Clare County, attracted attention to the Basin district. The Sun Oil Company's State-Winterfield No. A-1 (center, N. $\frac{1}{2}$, NE. $\frac{1}{4}$, SW. $\frac{1}{4}$ of Sec. 35) was completed, September 21, 1940, in the Dundee formation and pumped 50 barrels per day. The Rowmor Corporation and D. E. Hughes' Wyman No. 1 (center, W. $\frac{1}{2}$, SW. $\frac{1}{4}$, SE. $\frac{1}{4}$ of Sec. 29) which was completed, November 15, 1940, pumped 359 barrels per day. As these wells are 3 miles apart the district offers possibilities for much development during 1941.

In August, the Sun Oil Company drilled a wildcat in Sec. 15, T. 19 N.,R. 3 W., Hamilton Township, Clare County, which created much excitement when it flowed 1,512 barrels of 38° Bé. gravity oil per day from the Dundee. The well went dead in a few days and after all attempts to bring back production failed, the well was plugged.

In the Temple field, Clare County, activity was limited to the Redding pool (T. 19 N., R. 6 W.). During the year, twenty-six wells were drilled. Production reached the peak of 412,871 barrels in December, 1939, and declined gradually to 260,345 in December, 1940. At the end of the year the pool had produced approximately 3,800 barrels per acre.

Drilling in the Wise field in Isabella County (T. 15 N., R 4 W.) continued active, 43 producing wells having been completed during the year. Production reached a peak of 102,186 barrels in May and had declined to 48,239 by December.

Oil and gas discoveries during 1940 are listed in Table III.

DEEP TESTS

The Gulf Oil Company deepened its Bateson well No. 1 (center, S. $\frac{1}{2}$, SE. $\frac{1}{4}$, SE. $\frac{1}{4}$ of Sec. 2, T. 14 N., R. 4 E.) in the Kawkawlin field. The Kawkawlin structure had been previously surveyed by seis-

TABLE III

Discovery Wells in Michigan during 1940

County	Field	Location	Operator	Well	Date Completed	Total Depth	Initial Prod. Oil Bbls.	Initial Prod. Gas 1,000 Cu. Ft.	Formation	Remarks
				"BASIN"						
Arenac	Adams	22-19N- 3E	Don Rayburn	Yenior 1	7-18-40	2,879	1,981		Dundee	Extension
Clare	North Temple	11-19N- 6W	Sun Oil Company	State-Redding A-1	1-10-40	3,926	2		"Mich. Stray"	Plugged back to 1,425, now abnd.
Clare	Hamilton	26-19N- 3W	Sun Oil Company	Switzer 1	2-28-40	3,795 PB 1,268		206	"Mich. Stray"	Now plugged
Clare	Marion	19-20N- 6W	Taggart Bros. Co.	Woodin *et al.* 1	6-25-40	1,419		6,750	"Mich Stray"	
Clare	Hamilton	15-19N- 3W	Sun Oil Company	McKenna 1	8-11-40	3,753	1,512		Dundee	Now plugged
Clare	Winterfield	35-20N- 6W	Sun Oil Company	State-Winterfield A-1	9-21-40	3,798	50		Dundee	
Clare	Winterfield	29-20N- 6W	Rowmor Corporation and D. E. Hughes	Wyman 1	11-15-40	3,772	359		Dundee	
Gladwin	Grout	10-18N- 2W	Sun Oil Company	Cameron 1	6- 1-40	3,841	18		Dundee	
Gratiot	North Star	4-10N- 2W	Vic R. Wilson	2nd Nat. Bk. 1	10- 3-40	883		1,160	"Mich. Stray"	One Well
Missaukee	Riverside	22-21N- 7W	Taggart Bros. Co.	Quist 1	6-19-40	1,416		7,300	"Mich. Stray"	
Montcalm	Pine	27-11N- 8W	H. L. Gentry Eng. Co.	Packard 1 (Comm.)	9-17-40	1,146		250	"Mich. Stray"	
Montcalm	Six Lakes	20-12N- 7W	Belvidere Oil Co.	Bradley 1	9-28-40	1,307		1,840	"Mich. Stray"	Extension (?)
Montcalm	Richland	17-12N- 5W	E. C. Dailey	Church 1	2- 3-40	1,215		6,230	"Mich. Stray"	Extension (?)
Ogemaw	Foster	25-24N- 1E	Weber Oil Company	State OP-1		3,966	20		"Upper Monroe"	Plugged back to 3,924, not completed
Osceola	Reed City	31-18N-10W	Weber Oil Company	Gabel 1	10-24-40	3,639	29		"Monroe"	
Osceola	Reed City	30-18N-10W	Taggart Bros. Co.	Cornell-Lomp 55	11-15-40	1,245½		7,500	"Mich. Stray"	
				SOUTHWESTERN MICHIGAN						
Allegan	N. Overisel	8- 4N-14W	H. C. Nelson	Peters 1	6- 4-40	1,479	402		Traverse	
Allegan	S. Overisel	3- 3N-14W	Lang. & Lewis, Inc.	Nevenzel 1	3- 1-40	1,477	70		Traverse	Extension
Allegan	Casco	34- 1N-16W	Alfred Urion	Antonson 1	8-10-40	1,115	50		Traverse	One well
Allegan	Sec. 11—Overisel	11- 4N-14W	W. L. McClanahan	Campagner 1	12-19-40	1,578	139		Traverse	
Berrien	Niles	1- 7S -17W	Lakeland Oil Corp.	Plym 1	8-17-40	599	50		Traverse	One well
Cass	Edwardsburg	22- 8S -15W	Tamblyn Dev. Co.	Woolverton 1	9- 9-40	673	3		Traverse	One well
Kent	Sec. 8—Wyoming	8- 6N-12W	C. D. Harrison	Chapin 1	1- 8-40	1,837	10		Traverse	Reopened and plugged back to 1,805
Muskegon	Dalton	15-11N-16W	Shiffman & Skinner	Lund 1	2-23-40	2,280	20		Dundee	One well
Muskegon	Cedar Creek	32-11N-15W	R. C. Lentz, Trustee	Edelman 1	11- 2-40	1,149		176	"Berea"	One well
Ottawa	Holland	34- 5N-15W	Crown Dev. Co.	Reimold 1	2-28-40	1,525	250		Traverse	One well
Ottawa	Sec. 5—Tallmadge	5- 7N-13W	Daily Crude Oil Co.	Powell 1	11- 5-40	1,183	54		"Berea"	One well
VanBuren	Geneva	22- 1S -16W	Smith Petroleum Co.	Fellows 1	6-26-40	1,049	40		Traverse	
VanBuren	Mill Lake	15- 1S -14W	Clapsaddle & Harris	Peavey 1	10- 8-40	1,062	768		Traverse	Extension

mograph and also had been core tested. Production prior to deepening had been found in both the Dundee and the Detroit River (Devonian) formations. This well originally was to have been deepened to the St. Peter (Lower Ordovician) formation but on December 2, 1940, blew in at 7,776 feet near the base of the Salina (Silurian) salt section with a gas pressure upwards of 3,100 pounds at the well head. Shortly after the discovery of the gas, the well caught fire and the rig was destroyed. When finally brought under control, the well produced 50–100 barrels of 71° Bé. gravity condensate per day. At the close of the year, operators had rebuilt the rig with the intention of continuing drilling to the St. Peter formation. The well is being watched with great interest and several deep wells are projected pending the outcome of this test.

The Sun Oil Company drilled a wildcat in Barry County (Sec. 8, T. 3 N., R. 9 W.) to a depth of 5,013 feet. Showings of oil were reported at the horizon of the St. Peter, indicating that southwestern Michigan may have possibilities in the deeper zones.

GAS-TRANSMISSION LINES

The Consumers Power Company began construction of 57½ miles of welded 12¾-inch line from the Riverside gas field southeastward through the Marion field to connect with their present 8-inch line. approximately 6 miles west of Midland. Feeder lines were projected to connect Lincoln field in Clare County and Wise field in Isabella County to this new line.

In April, the Dow Chemical Company completed its 6-inch welded line from the Temple field to its main plant in Midland.

The Gas Corporation of Michigan built a 4½-inch line from the Freeman field in Clare County to the City of Clare to connect with its existing line.

Oil pipeline construction was limited to gathering lines to service field extensions.

In view of the reported leasing interest in wildcat areas, further development of 1940 discoveries, and the possibility of new deep producing zones, 1941 promises to be an active year in Michigan.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1135-1148, 1 FIG.

DEVELOPMENTS IN APPALACHIAN AREA DURING 1940[1]

APPALACHIAN GEOLOGICAL SOCIETY[2]
Charleston, West Virginia

ABSTRACT

NEW YORK. In the Oriskany sand area of southern New York, 52 wells were completed during 1940, 19 as gas wells with a combined daily open flow of 95,825,000 cu. ft., and 33 as dry holes, of which 24 were wildcat wells. Three new producing areas were discovered, located in Steuben, Allegany and Chemung counties. All of these fields appear to be small and do not equal the depletion suffered by older producing fields. Only one test in the area was drilled below the Oriskany and was dry through the Medina sands (Silurian) at a total depth of 6,825 feet.

PENNSYLVANIA. The Bradford area continued to lead in oil production in Pennsylvania, producing 14,285,000 barrels, or 52.9 per cent of the Pennsylvania crude production, the greater portion of which was produced by intensive water drive. The limits of the Music Mountain field were defined during the year with a total of 210 oil wells and 14 gas wells producing from the Sliversville sand (Upper Devonian). In the Summit Oriskany gas field located in Fayette County, 3 gas wells were completed and 2 Onondaga chert wells were successfully deepened to the Oriskany. The field is now 2½ miles in length and 2,400 feet in width and trends N. 30 E. To date 8 producing wells and one dry hole have been drilled. In Beaver County the first test to penetrate the Medina sand (Silurian) was completed as a dry hole at 6,823 feet. In this county a wildcat well is being drilled to the Oriskany and another in Mercer County. In Erie County a St. Peter test was recently abandoned with a show of oil, gas and water in this horizon. In the Oriskany producing area of northern Pennsylvania no new fields were developed.

OHIO. During 1940, 1,228 tests were completed in horizons ranging from upper Pennsylvanian to lower Silurian. Of these, 327 were oil wells, 491 gas wells and 410 were dry holes. The oil wells averaged 13.7 barrels, and the gas wells averaged 582,000 cu. ft.

WEST VIRGINIA. Practically all of the deep drilling in the state during the year 1940 was confined to the Oriskany sand (Lower Devonian) gas fields of Kanawha and Jackson counties. The Elk-Poca gas field was extended west and north, and 106 wells were completed with 479,987,000 cu. ft. of open flow developed. Approximately 50 wells were deepened, some of which encountered new gas pays at deeper zones in the Oriskany sand. Two tests below the Oriskany encountered water in the Newburg sand (Silurian). In northern Jackson County the New Sandyville Oriskany gas field now has 9 wells scattered over a narrow north-south area. In other areas in the state deeper drilling was not particularly encouraging. Seven hundred eighty-two drilling permits were issued during the year, 439 were gas wells, 70 oil wells, 22 combination oil and gas wells, and 134 dry holes. The others were either commercial water wells, pressure wells, abandoned locations, or unreported.

KENTUCKY. In eastern Kentucky during the year 1940, 223 wells were reported, 74 as oil wells, 99 as gas wells, and 50 as dry holes. Oil and gas was produced from beds of Mississippian, Devonian, Silurian, and Ordovician ages. Two million, fourteen thousand, one hundred forty-one barrels of oil were produced, coming mainly from the Weir sand. Recent production of oil and gas from the Brassfield (Silurian) is encouraging. Two deep Knox tests are reported as dry, and 5 were drilling at the end of the year.

[1] Presented by title before the Association at Houston, April 4, 1941. Manuscript received, April 18, 1941.

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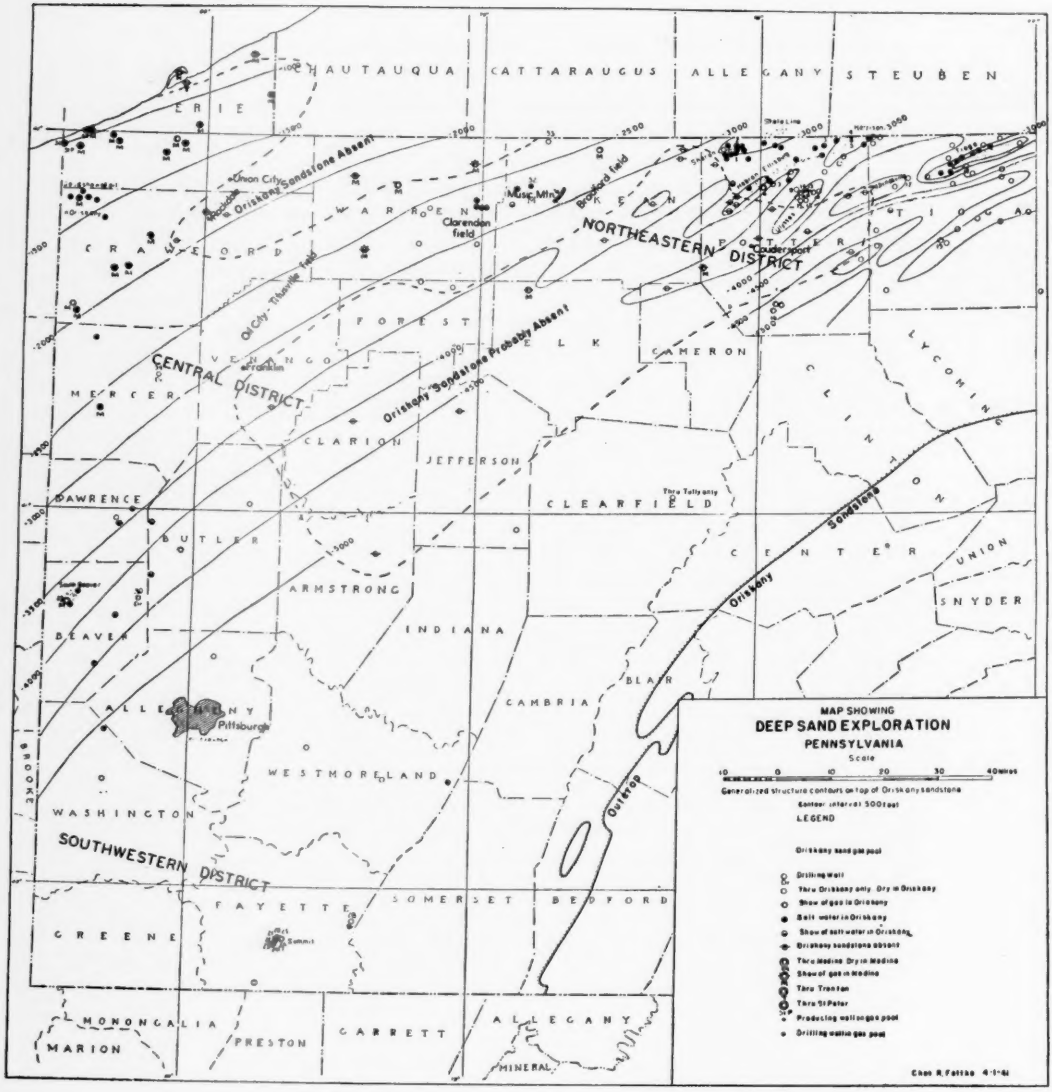
CHAUTAUQUA
CATTARAUGUS
ALLEGANY
STEUBEN
ERIE
CRAWFORD
WARREN
MCKEAN
POTTER
TIOGA
FOREST
ELK
CAMERON
VENANGO
MERCER
CLARION
JEFFERSON
LYCOMING
CLINTON
CENTER
UNION
SNYDER
LAWRENCE
BUTLER
ARMSTRONG
INDIANA
BLAIR
CAMBRIA
BEAVER
ALLEGHENY
Pittsburgh
WESTMORELAND
WASHINGTON
BROOKE
FAYETTE
SOMERSET
BEDFORD
GREENE
MONONGALIA
MARION
PRESTON
GARRETT
ALLEGANY
MINERAL
FRANKLIN
Union City
Oriskany Sandstone Absent
Oil City-Thurmont field
Clarendon field
Bradford field
Kane
Smethport
Coudersport
Wellsville
Harrison
State Line
NORTHEASTERN DISTRICT
CENTRAL DISTRICT
Oriskany Sandstone Probably Absent
Thru Tully only
Oriskany Sandstone
Outcrop
SOUTHWESTERN DISTRICT
MAP SHOWING
DEEP SAND EXPLORATION
PENNSYLVANIA
Scale
10 0 10 20 30 40 Miles
Generalized structure contours on top of Oriskany sandstone
Contour interval 500 feet
LEGEND
Oriskany sand gas pool
Drilling well
Thru Oriskany only Dry in Oriskany
Show of gas in Oriskany
Salt water in Oriskany
Show of salt water in Oriskany
Oriskany sandstone absent
Thru Medina Dry in Medina
Show of gas in Medina
Thru Trenton
Thru St Peter
Producing well on gas pool
Drilling well on gas pool
Chas R. Fettke 4-1-41

FIG. 1

NEW YORK

In the Oriskany sand area of southern New York, which includes Allegany, Steuben, Chemung, Schuyler, and Tompkins counties, fifty-two wells were completed during 1940. Of these, nineteen were gas wells with a combined daily open flow of 95,825,000 cubic feet and thirty-three were dry holes. Of the dry holes, twenty-four were wildcat wells. Three new producing areas were found during the year. The first two of these are in the town of West Union, Steuben County, and the town of Independence, Allegany County. They are now being developed and little is known about the reserves of gas they may have although it is generally believed that they will be small. The third area is immediately south of Elmira in Chemung County and appears at this time to be relatively unimportant.

Production during the year in the Oriskany area continued to decline rapidly and the development of reserves by new drilling failed to equal the depletion.

Only one well was drilled in the area in 1940 to test formations below the Oriskany. This well is situated in the town of Irwin, Steuben County. It was dry and abandoned in February, 1941, at a depth of 6,825 feet, after having tested the Medina sands.

PENNSYLVANIA[3]

OIL DEVELOPMENTS

Southwestern Pennsylvania.—In the southwestern district (Allegheny, Armstrong, Beaver, Fayette, Greene, and Washington counties) there was little oil development. Secondary recovery methods are in operation on only a few leases, although they have been successful where tried. Wells and some whole pools are being stripped of their equipment and abandoned throughout the southwestern district. According to the *Oil and Gas Journal*, 25 oil wells were drilled in this district in 1940, with an average initial production of 8 barrels per day.

Central district.—In the Oil City-Titusville area, comprising parts of Crawford, Venango, Forest, and Warren counties, the development of properties subject to air and gas drive continued, although at a slower rate than for several years. A small amount of additional acreage was drilled for water-flooding in the Clarendon pool. In the rest of the Central District, including Butler, Clarion, and southern Venango counties, there was some drilling, but for the most part there was little activity and some leases are being abandoned.

During the summer of 1940 an attempt was made to exploit the

[3] Published by permission of the State geologist of Pennsylvania.

TABLE I

Wells Completed and Drilling in Summit Pool, Fayette County, Pennsylvania, during 1940

Map No.	Township	Well	Company	Feet Elevation	Feet Depth to Tully	Feet to Top Onondaga Lime-	Feet to Top Cherl	Feet to Oriskany	Feet Total Depth	Date Completed	Results
20	North Union	Piedmont Coal Co. 1	Wm. E. Snee & New Penn Dev. Corp.	2,178	6,060–6,190	6,662	6,692	7,042–	7,058	5-27-40	First gas at 6,792 feet, additional at 6,826 feet, 7,006–7,055 feet, 2,300,000 cubic feet
21	South Union	Piedmont Coal Co. 2	Peoples Natural Gas Co.	2,024	5,720–	6,381	6,420	6,691–	6,817	11-26-40	First gas at 6,422 feet, 2,724,000 cubic feet. 2,225 pounds rock pressure
22	South Union	Piedmont Coal Co. 3	Peoples Natural Gas Co.	2,405	6,048–6,171	6,746	6,801	7,086–7,243		Drilled to 7,264 feet 3-15-41	Gas at 7,257 feet, 2,800,000 cubic feet. 2,200 pounds rock pressure
23	South Union	Piedmont Coal Co. 4	Peoples Natural Gas Co.	2,568							Drilling
24	South Union	Leo F. Heyn, No. 3	Wm. E. Snee & New Penn Dev. Corp.	2,314	5,845–5,915	6,365	6,395	6,579–			Drilling at 6,609 feet
25	North Union	Mrs. J. H. Sorg, No. 2	W. W. Wasson *et al.*	2,499	6,351–						Drilling
			Wells Deepened during 1940								
26	South Union	Leo F. Heyn, No. 1	Wm. E. Snee & New Penn Dev. Corp.	2,316	6,021–6,100	6,572	6,593	6,772–	6,842	11- 5-40	Deepened from 6,690 feet. 500,000 cubic feet. Additional gas in Oriskany at 6,781 feet
27	South Union	Leo F. Heyn, No. 2	Wm. E. Snee & New Penn Dev. Corp.	2,464	6,085–	6,672	6,682	6,834–	6,984	9-16-40	Deepened from 6,767 feet. 2,250,000 cubic feet gas at 6,838–6,885 feet

Heavy Crude pool at Franklin, Venango County, by means of horizontal wells. The plan was to drill four horizontal wells in the sand, converging from four different directions on a central vertical well. The sand lies 400–600 feet below the surface, and there is from 30–60 feet of pay. The horizontal wells were to be started at the surface, dipping downward at an angle of 20°–30°, and when the sand was encountered, the holes were to be wedged upward so that they would continue from this intersection to the vicinity of the vertical well through the middle of the sand. The vertical well was put down with a diamond-core drill, and the same machine was used for the first angle hole, which reached the top of the sand with no difficulty. Repeated attempts to set wedges and raise the inclination of the hole to horizontal were made in several inclined holes, but none was successful. The operators became discouraged, and the project was abandoned. Since no horizontal holes were obtained, the experiment provided no information on the possibilities of producing oil by horizontal drilling.

No record of the number of wells drilled in the Central district is kept.

Bradford district.—The Bradford field, approximately 14 per cent of whose area lies in New York state, accounted for 52.9 per cent of the total Pennsylvania grade crude-oil production. This 65-year old field with a production of 14,285,000 barrels[4] during the year still ranked ninth among the leading oil fields of the United States. Almost all the oil recovered from the Bradford pool at the present time is obtained through intensive methods of water-flooding. In 1930, 3,004 new wells[4] were drilled, about half of which were intake wells.

The Music Mountain field was the scene of much drilling during 1940. This field was discovered on August 24, 1937, when a wildcat well of the Niagara Oil Corporation came in flowing at a rate of 44 barrels per hour from a local sand known as the Sliverville, 240 feet above the Bradford Third sand. By the end of 1940, a total of 210 producing wells, 14 gas wells, and 68 wells unproductive in the Sliverville sand had been drilled. A few of the largest wells began producing at the rate of 500 barrels per hour. The limits of the pool were well established by 1940. The productive area consists of a strip 4 miles long and 800 to 2,000 feet wide. The total production at the end of 1940 is estimated at 2,235,000 barrels. Although flowing wells were completed as late as the summer of 1940, at the end of the year almost all wells were being pumped.

During the fall of 1940 two wells were completed a short distance southwest of the southwest tip of the Music Mountain pool, one of

[4] *The Producers Monthly* (February, 1941)

which was reported to have had an initial production of 500 barrels of oil and 500,000 cubic feet of gas per day, and the other to have had an initial production of 5 million cubic feet of gas and later flowed oil. A reservoir pressure of 500 pounds per square inch was measured in these wells in contrast to the 240 pounds measured in wells at the southwestern end of the main pool. There is a possibility that these wells may be located at the northeast end of another lens of Sliverville sand separated and slightly offset from the Music Mountain sand body but located along the same trend. The wells have been shut in since they were drilled.

GAS DEVELOPMENTS

Southwestern Pennsylvania.—In the Summit gas pool on the Chestnut Ridge anticline in Fayette County, three new wells were completed during 1940 and early 1941, and three others are drilling. In addition, two wells that had been producing from the chert beds of the Onondaga formation were deepened through the Oriskany sandstone. The new development work, summarized in Table I, was confined to the northwest side of the pool. As now developed, the pool occupies a narrow belt about 2½ miles long and 2,400 feet wide which trends approximately N. 30° E. Eight producing wells and one dry hole have been completed. Production is obtained both from the cherty Onondaga formation and the Oriskany sandstone.

TABLE II

SHALLOW WELL COMPLETIONS IN SOUTHWESTERN PENNSYLVANIA, 1940
(From *Oil and Gas Journal*)

County	*Completions*	*Gas*		*Oil*		*Dry*	*Average Total Depth, Feet*
		No. of Wells	*Aver. Initial Open-Flow Capacity, 1,000 Cubic Feet per Day*	*No. of Wells*	*Aver. Initial Production, Barrels per Day*		
Allegheny	19	6	85	9	10	4	1,954
Armstrong	71	59	175	1	5	11	3,101
Beaver	3	—	—	1	1.5	2	850
Butler	45	10	25	27	2.5	8	2,309
Clarion	33	31	70	—	—	2	2,409
Fayette	26	24	490	1	5	1	2,163
Greene	47	42	700	1	3	4	2,757
Indiana	51	24	230	—	—	27	2,994
Washington	47	25	470	12	8	10	2,257
Westmoreland	26	22	150	—	—	4	3,364

Wm. E. Snee and the New Penn Development Company's Gregg L. Neel No. 1 (Map No. 28), which is testing a structure along the Laurel Hill anticline in the northeastern part of Stewart Township in eastern Fayette County, was drilled to a depth of 8,002 feet without

reaching the top of the Onondaga. The well appears to have passed through a fault.

In western Fayette County drilling for gas in the Big Injun and Fifth sand of Mississippian and Devonian ages shifted from Menallen Township in the central part of the county to Nicholson Township in the southwestern part. Several large gas wells were also completed in the Big Injun sand in Monongahela Township in southeastern Greene County.

The Texas Company had one or two seismograph crews working in southwestern Pennsylvania during a considerable part of the year. Some leases were taken in the old Candor field of northern Washington County, and adjacent parts of Allegheny County.

Central district.—In Clarion, Armstrong, Indiana, and Westmoreland counties, most of the wells were completed in the Bradford sand, the deepest of the so-called shallow sands that has thus far been found productive in this part of the state. One well drilled in 1940 to this formation in Fayette County encountered commercial volumes of gas, indicating that the Bradford sand may be productive in parts of that county also. In Armstrong County, the greatest activity was in Cowanshannock Township in the vicinity of the Bradford sand gas pool opened in 1939.

In the South Beaver Township Oriskany sand pool, Beaver County, Jas. H. Duff and John T. Galey deepened their James L. Tennis Heirs' well No. 1 through the Medina sandstone. Below the Oriskany a very slight showing of gas was encountered in the Lockport dolomite at 6,260 feet. Otherwise the formations were dry. Inasmuch as this is the first well to have been completed through the Medina in southwestern Pennsylvania, a skeleton log is here given.

SKELETON LOG OF JAS. H. DUFF AND JOHN T. GALEY'S JAMES L. TENNIS HEIRS' WELL NO. 1 (MAP NO. 29)

South Beaver Township, Beaver County, Pennsylvania
Drilled to depth of 4,613 feet, October 6 to December 15, 1937
Deepened to 6,822 feet, February 21 to April 26, 1940
Elevation, 982.6 feet above sea-level

		Depth in Feet	
		Top	*Bottom*
Pennsylvanian system			
Allegheny group		0	123
Pottsville series		123	331
Mississippian system		331	797
Berea sandstone	684– 720		
Gas sand	750– 797		
Devonian system			
Upper Devonian series		797	4,249
Tully limestone	4,243–4,249		
Hamilton group		4,249	4,405
Onondaga limestone		4,405	4,599

Oriskany sandstone		4,599	4,670
Gas	4,607-4,613		
Helderberg group		4,670	4,870
Silurian system		4,870	6,015
Salina group	4,930-6,015		
Salt	5,113-5,160		
	5,176-5,228		
	5,280-5,288		
	5,350-5,353		
	5,462-5,465		
	5,494-5,501		
	5,513-5,523		
Middle Silurian series		6,015	6,588
Lockport dolomite	6,015-6,293		
Very small showing of gas at.	6,260		
Clinton group		6,293	6,588
Lower Silurian or Medina series		6,588	6,761
Red Medina or Grimsby		6,588	6,663
White Medina or Whirlpool		6,663	6,761
Ordovician system			
Queenston shale		6,761	6,823
Total depth			6,823

D. D. McMichael *et al.* are engaged in drilling an Oriskany sand test on the Elmer Pflug farm (Map No. 30), in New Sewickley Township, Beaver County. It has reached a depth of 3,017 feet. The well is located on a "seismic high" with a closure of 40 feet, mapped by the Geophysical Company of Parkersburg, West Virginia.

Beal and McCandless of Pittsburgh, at the close of 1940, were drilling a deep test on the J. Paul Miller farm (Map No. 34), in Lake Township, Mercer County.

On the Jay Childs farm, Springfield Township, Erie County, in the extreme northwestern corner of the state, the Ohio Oil Company drilled a well into what probably represents the St. Peter sandstone of the Ordovician (Map No. 31). A showing of oil was encountered in the Trenton limestone, and a slight showing of oil and gas in the St. Peter sandstone. This is the second well in western Pennsylvania to reach the Trenton and the first to reach the St. Peter. The well was plugged and abandoned in April, 1941. The following partial log of the well shows the position of some of the more important formations.

PARTIAL LOG OF OHIO OIL COMPANY'S JAY CHILDS WELL NO. 1

Springfield Township, Erie County, Pennsylvania
Elevation, 638 feet

	Depth in Feet	
	Top	*Bottom*
Onondaga limestone	1,392	1,662
Oriskany sandstone	1,662-	
Salt water		
Red Medina—Grimsby	2,624	2,660
White Medina—Whirlpool	2,660	2,763
Top of Trenton limestone	4,437	
Showing of oil, about 1 barrel per day, 4,441 feet		
Top of sandy zone	5,150	
St. Peter sandstone	5,177	5,191
Slight showing of oil and gas and a little salt water		

During 1939 and 1940, White and Mitchell of Cambridge Springs drilled nine wells in and near Rockdale Township, Crawford County. Initial open flows of gas up to 300,000 cubic feet per day were encountered in eight of them between 900 and 1,000 feet, or approximately the Clarendon-Speechley horizon of the Upper Devonian. These wells have not yet been allowed to produce, and the potential reserves of the area are thus impossible to estimate. The Potter Development Company had previously drilled a deep well in this area which found an open flow of 310,000 cubic feet of gas in a broken sand between 1,000 and 1,019 feet, but which had exhausted itself by the time the well was drilled through the Medina.

Schreffler Brothers of Kane drilled two wells near Union City, one of which encountered a strong flow of gas at about the same horizon, which exhausted itself in a few days. At least part of the gas encountered in the Upper Devonian in this region is shale gas, and no large production has ever been developed.

The Gulf Oil Corporation had two seismograph crews working in Erie, Crawford, and Mercer counties during the field season of 1940. The Magnolia Petroleum Company also did a little work along the western borders of these counties. None of these companies is reported to have taken any leases in the area explored.

Northeastern district.—The Hiawatha Oil and Gas Company of Pittsburgh completed two Oriskany sand tests in McKean County during 1940 with the following results.

	Hiawatha Oil and Gas No. 1 (Map No. 32) Warrant 3705, Corydon Township Elevation, 1,603 feet	Hiawatha Oil and Gas No. 2 (Map No. 33) Warrant 4917, Foster Township Elevation, 2,052 feet
Onondaga limestone	4,166–4,231	4,338–4,417
Oriskany sandstone	4,231–	4,417–4,431
Total depth	4,241	4,480
Date completed	4-19-40	10-12-40
Results	Salt water from Oriskany ran over top of casing and could not be bailed off	Dry in Oriskany

In Potter County a small amount of shallow-sand gas was developed in a new area in the vicinity of Coudersport.

The major Oriskany gas developments in Pennsylvania have been confined to northern Tioga and Potter counties. Northwest of the Allegheny front in north-central Pennsylvania, the Sabinsville anticline, the fourth of the prominent folds in that direction, distant about 40 miles from the front, is the first one along which commercial pro-

duction has been obtained. The Sabinsville and Tioga fields are located along it about 10 miles apart. One major pool in Pennsylvania, the Harrison, and one minor pool, the Ulysses, have been developed along the Harrison anticline, the next anticline northwest of the Sabinsville. Along the Hebron anticline, the next northwest of the Harrison, two major pools, the Hebron and the Ellisburg, and three minor pools have been opened up. Along the Smethport anticline, the next northwest of the Hebron, two fields, the Sharon and the State Line, have been developed. The major part of the latter, however, is in New York state. Each of these fields occurs on a well defined dome, in some places complexly modified by faulting. Although tests have been made on equally well defined structures along the anticlines southeast of the Sabinsville in Bradford, Tioga, and Potter counties, none of them has produced. The Oriskany sandstone was found but it was so tightly cemented and recrystallized that it was no longer capable of acting as a reservoir rock for the retention of fluids.

Exploration along the Sabinsville, Harrison, Hebron, and Smethport anticlines had extended southwest into the area in which the sand was absent by the end of 1939. There is, therefore, little likelihood that any additional major pools remain to be discovered in the Oriskany sand in north-central Pennsylvania. The discoveries of additional reserves of gas in this area, if any, will be confined largely to the borders of the fields already developed where some detached fault blocks with sufficient closure may still remain to be discovered. Only nineteen wells were completed through the Oriskany in north-central Pennsylvania during 1940 and the results were disappointing, as shown in Table III.

One well at the end of 1940, located in the southwestern part of Potter County, had tested the possible producing formations below the Oriskany in the north-central Pennsylvania area. It passed through the Medina sandstone and found it dry, but the well was not located on one of the more prominent structures. The deep sand possibilities of the area, therefore, can not be considered to be entirely exhausted.

OHIO

During 1940 a total of 1,228 tests were completed in Ohio in horizons ranging in age from upper Pennsylvanian to Lower Silurian. Of these 327 were oil wells, 491 gas wells and 410 were dry holes. The average initial production per oil well was 13.7 barrels and the average initial open flow per gas well was 582,000 cubic feet.

About 400,000 acres were leased in the eastern half of the state dur-

TABLE III

ORISKANY SAND WELLS COMPLETED IN NORTH-CENTRAL PENNSYLVANIA DURING 1940

(Depths Shown in Feet)

Map No.	Township	Well	Company	Elevation	Tully	Onondaga	Oriskany	Total Depth	Date Completed	Results
			POTTER COUNTY							
1	Sharon	Dunshie 2	New Penn Development Corp.	1,960	4,303–4,360	4,942–4,992	4,992–	4,997	1-19-40	Salt water at 4,995
2	Oswayo	R. C. Holmes	Empire Gas & Fuel Co.	1,936	4,246–4,298	4,773–4,824	4,824–	4,826	11-27-40	Salt water at 4,826
3	Bingham	Frederick W. Clark	C. E. Updegraff *et al.*	2,330	4,826–4,887	5,461–5,497	5,497–	5,504	6-14-40	Salt water at 5,502
4	Harrison	S. W. Berry	New Penn Development Corp.	2,228	4,444–4,498	5,115–5,146	5,146–	5,157	8-29-40	3,200,000 cubic feet gas, 585 pounds rock pressure
5	Harrison	Howard White	New York State Natural Gas Co.	2,160	4,348–4,420	5,037–5,059	5,059–	5,079	12- 8-40	600,000 cubic feet gas
6	Hebron	Burt & Lyman 2	New York State Natural Gas Co.	2,243	4,932–4,986	5,525–5,545	5,545–5,563	5,570	8-30-40	143,000 cubic feet, 1,150 pounds rock pressure
7	Allegany	Frank Osgood	Hanley and Bird & Allegany Gas Co.	2,056	5,000–5,070	5,641–5,659	5,659–5,687	5,692	4-26-40	Dry
8	Allegany	William Cobb	New York State Natural Gas Co.	2,268	4,939–4,992	5,589–5,607	5,607–5,618	5,636	5- 1-40	Dry
9	Allegany	Mamie Cole	Allegany Gas Co.	2,272	5,135–5,190? 5,282–5,312?	6,355–6,379	6,379–6,402	6,402	7-30-40	Showing salt water, 6,386–6,388
10	Ulysses	M. F. Kidney	Godfrey L. Cabot, Inc.	2,390	4,457–4,516	5,104–5,133	5,133–5,150	5,285	1-27-40	Showing of gas
11	Ulysses	Joseph Torok	Godfrey L. Cabot, Inc.	2,497	4,563–4,616	5,202–5,216	5,216–5,231	5,238	1-29-40	556,000 cubic feet gas, 2,200 pounds rock pressure
12	Ulysses	John Stone 4	Godfrey L. Cabot, Inc.	2,212	4,321–4,375	4,965–4,984	4,984–5,010	5,116	3- 6-40	Dry
13	Ulysses	J. J. Morley	Williamsport Natural Gas Co.	2,430	4,496–4,549	5,136–5,158	5,158–5,171	5,173	4-18-40	880,000 cubic feet gas, 1,730 pounds rock pressure
14	Ulysses	J. J. Morley	Godfrey L. Cabot, Inc.	2,402	4,481–4,536	5,129–5,140	5,140–5,157	5,157	7-26-40	60,000 cubic feet gas, 1,265 pounds rock pressure
15	Ulysses	L. L. Rennels	Godfrey L. Cabot, Inc.	2,411	4,456–4,509	5,098–5,121	5,121–5,140	5,152	11-22-40	Dry
16	Wharton	Central Pennsylvania Lumber Co.	Godfrey L. Cabot, Inc.	1,990	5,583–5,647	6,300–6,325	6,325–	6,337	12- 2-40	157,000 cubic feet gas
			TIOGA COUNTY							
17	Chatham	D. F. Tremaine	New York State Natural Gas Co.	1,683	4,423–4,488	5,242–5,253	5,253–5,274	5,296	4-10-40	Dry
18	Farmington	George Colegrove	Allegany Gas Co.	1,713	4,200–4,264	5,140–5,172	5,172–5,214	5,218	5-14-40	Dry
19	Delmar	D. K. Campbell	Wm. E. Snee & Allegany Gas Co.	1,780	4,550–4,626	5,517–5,529	5.529–5.569	5,714	1-23-41	Showing gas at 5,541

ing the year on the prospect of production deeper than had been previously developed in that area. Several Clinton tests were completed on this acreage the deepest of which reached a total depth of 5,800 feet. Although no new production was encountered considerable wildcat activity is anticipated in that section during 1941.

Completions in Ohio by sands are shown in the following table.

Sands	Oil Wells		Gas Wells		Dry	Total
	No. of Wells	Average Initial Production Barrels	No. of Wells	Average Initial Production 1,000 Cubic Feet		
Shallow	75	5.5	92	325	93	260
Berea	184	7.8	125	105	153	462
Ohio shale	0	—	18	83	2	20
Oriskany	0	—	3	134	2	5
Newburg	2	20.0	21	977	5	28
Clinton	57	44.4	229	967	141	427
Trenton	8	11.8	3	201	7	18
Sub-Trenton	1	1.0	0	—	7	8
Total or average	327	13.7	491	582	410	1,228

WEST VIRGINIA

Practically all of the deep drilling in the state during the year 1940 was confined to the Oriskany sand (Lower Devonian) gas fields of Kanawha and Jackson counties.

The Elk-Poca field was extended west and north, adding perhaps 10 square miles to the proved area. One hundred six gas wells were completed with 479,987,000 cubic feet of open flow developed. Volumes ranged from 119,000 to 18,630,000 cubic feet, with an average of 4,528,000 cubic feet. No completely dry holes were drilled in the field although, as indicated, some were small. To the end of the year, 416 gas wells had been completed with initial open flow developed to the amount of 2,853,000,000 cubic feet.

Approximately 50 wells were deepened in the Oriskany sand, some of which developed new gas pays at deeper zones in the sand, with rock pressures in excess of prevailing pressures in the upper "pays."

Two wells are being deepened from the Oriskany in this field. Both of these wells encountered salt water in the Newburg sand (Silurian). This is especially significant in that previous tests in the general area of this field had encountered completely calcium carbonate-cemented sand. These two wells are expected to test the Clinton sand (Medina-Silurian), which should be reached at 1,500–1,700 feet below the Oriskany.

In northern Jackson County at the end of 1940, nine Oriskany sand gas wells were spread in a narrow north and south line approximately 20 miles in length with the village of Sandyville near the center. The Appalachian Geological Society committee on nomenclature has suggested that the name Sandyville be used for this field. Initial open flows range from 231,000 to 16,000,000 cubic feet, with rock pressures ranging from 1,700 to 1,800 pounds.

In Boone County, one well in the Campbell-Davis Creek Oriskany field was completed with an open flow of 997,000 cubic feet and one well was dry through the Oriskany.

In Wayne County, two deep tests were completed. One in the Ceredo district was dry through the Clinton sand at a total depth of 4,267 feet, and the other in the Lincoln district was abandoned at a total depth of 3,819 feet in the Salina (Silurian), due to encountering hydrogen sulphide gas with a concentration of 25.4 per cent, or 16,000 grains per 100 cubic feet.

In Harrison County, Grant district, the first rotary in the state is reported as dry through the Oriskany sand at 7,360 feet and still drilling.

The State Bureau of Mines issued 782 drilling permits in 1940. Of these, 439 were completed as gas wells, 70 as oil wells, 22 as combination oil and gas wells, and 134 as dry holes. The remainder were either commercial water wells, pressure wells, abandoned locations, or unreported.

KENTUCKY

The year of 1940 witnessed no outstanding development in eastern Kentucky. Completions were reported from 21 counties east of the axis of the Cincinnati arch, testing beds from Pennsylvanian to the Knox dolomite.

There were 223 wells reported, 74 of which were oil, 99 gas, and 50 dry holes. The production from eastern Kentucky totaled 2,014,141 barrels. Oil and gas were produced from beds of Mississippian, Devonian, Silurian, and Ordovician ages.

The greater part of the oil was produced from the Weir sand of lower Mississippian age, and the "Corniferous" of Devonian and Silurian ages. Drilling in the large Ohio Shale (Chattanooga) gas field was limited to a sufficient number of wells to maintain market requirements.

Much interest is being manifested in the possibilities of deep drilling in eastern Kentucky. Several large blocks of leases are being held by major companies, as well as individual operators on such outstand-

ing structural features as the Paint Creek uplift, Rockcastle River uplift, and adjacent to the Irvine-Paint Creek fault zone.

A Knox test will be drilled by the Globe Oil and Gas Company *et al.* on the Sewell tract about 7 miles southwest of London in Laurel County. The location is near the crest of the Sinking Creek dome.

Another test of the Knox is being drilled on the Burke dome, northeast of Sandy Hook in Elliott County, by the Inland Gas Corporation *et al.*

Bailey No. 44, originally a "Corniferous" test, is being deepened by the Cumberland Petroleum Company *et al.* It will probably be drilled to the Knox.

W. O. Allen and W. W. McClure are drilling a Knox test in Clark County near Ruckerville.

Weaver *et al.* report a Knox completion with a showing of dead oil near Minerva in Mason County.

George Rabbitfoot *et al.* are drilling a proposed Knox test on the Shoun tract, 2½ miles north of Somerset in Pulaski County.

T. Petty completed a dry Knox test on the Barger in the Russell Springs area of Russell County.

Recent production of oil and gas from the Brassfield is stimulating exploration below the Chattanooga shale and the "Corniferous." This will possibly result in new oil and gas fields in the "Corniferous," Big Six, and Brassfield. Any new discoveries in these formations will result in the deepening of many of the wells in the shale gas field, as well as the "Corniferous" fields of eastern Kentucky.

Results of deep drilling during the year of 1940 have not been particularly encouraging. Numerous zones of porosity, including sand lenses, exist in the Knox dolomite. Showings of oil and gas encountered in the top of the Knox dolomite in Lee and Clinton counties in previous years were of sufficient importance to indicate those formations might be commercially productive in other parts of the state, particularly in eastern Kentucky.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1149-1158, 3 FIGS.

DEVELOPMENTS IN ROCKY MOUNTAIN DISTRICT IN 1940[1]

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ABSTRACT

There were no major discoveries of oil and gas in unproved areas in the Rocky Mountain district in 1940, most of the drilling being restricted to inside locations in major fields.

In Wyoming, good showings of oil encountered in the Shannon sandstone member of the Steele shale (Upper Cretaceous) in the Cole Creek field during deeper drilling in 1937 and thereafter, were tested further in 1940 and commercial production found; one relatively small oil well was drilled in the North Labarge field, Sublette County, 2½ miles north of the nearest production in the Labarge field; and wells deepened a few feet in the Tensleep sandstone (Pennsylvanian) in the Mahoney field, Carbon County, and to the basal member of the Tensleep in the Lost Soldier field, Sweetwater County, were good oil wells. During 1940, commercial amounts of oil were first found in the Tensleep in the East Mahoney (West Ferris) field, Carbon County. No new producing zones were found elsewhere in the Rocky Mountain district during 1940. However, in February 1941, commercial amounts of oil were first found in the Sundance formation (Upper Jurassic) in the Wilson Creek field, Rio Blanco County, Colorado.

In Wyoming, the Frannie field, Park County, was extended almost ½ mile northwestward into Carbon County, Montana; Sundance production was extended eastward about ½ mile in the Lance Creek oil field, Niobrara County; the present north end of the Labarge oil field was extended westward by relatively active drilling; and Tensleep sandstone production was extended about ¼ mile northeast inthe Wertz oil field, Carbon County. Gas production in the Frontier sandstone (Upper Cretaceous) was extended about ½ mile northwestward in the Muskrat field, Fremont County, and almost ½ mile southeastward in the near-by Big Sand Draw field. In the Hiawatha field, Sweetwater County, commercial gas was found in the Wasatch formation (Eocene) about a mile north of the nearest producer.

In Colorado, a good Morrison (Upper Jurassic) sand well was found in the Wilson Creek oil field, Rio Blanco County, ¾ mile southwest of the nearest producer; and on the east side of the Hiawatha oil and gas field, Moffat County, one relatively large oil well and one relatively small one were found in sandstones of the Wasatch formation.

During the year, very few important wildcat wells were drilled in the district. In Montana, a 7,116-foot dry hole was drilled through the Sundance sand on the Absarokee structure, Stillwater County. In Wyoming, a 6,302-foot dry hole was drilled to Pennsylvanian beds in the Middle Baxter Basin area, being the first well to test certain lower zones in the Rock Springs uplift; a 4,243-foot dry hole was completed in the Deadwood formation (Cambrian) on the Bull Creek structure, Crook County; and an 8,343-foot dry hole was completed in the Tensleep sandstone on North Geary dome, Natrona County.

A new depth record for drilling in Wyoming was established at 10,121 feet in the Badger Basin field, Park County.

Several relatively short pipe lines were completed in the district during 1940, one of the larger being the 100-mile line between the Billy Creek gas field, Johnson County. Wyoming, and the Big Sand Draw gas line at Casper.

INTRODUCTION[3]

The Rocky Mountain district in the year 1940 had no major discoveries of oil and gas in unproved areas; in fact, there was a notable

[1] Read before the Association at Houston, April 3, 1941, with the permission of the director of the Geological Survey. Manuscript received, March 24, 1941.

[2] Geological Survey, United States Department of the Interior.

[3] Appreciation is expressed to the petroleum engineers of the Geological Survey, United States Department of the Interior, and to C. E. Shoenfelt of Petroleum Information, Inc., Denver, Colorado, for many of the data contained herein.

decrease in drilling operations in the district, except in the Cut Bank and Kevin-Sunburst fields, Montana. Important discoveries of new producing zones in old fields included (1) the finding of commercial amounts of oil in the Tensleep sandstone (Pennsylvanian) in the East Mahoney (West Ferris) field, Carbon County, Wyoming, and, in February, 1941, in the Sundance formation (Upper Jurassic) in the Wilson Creek field, Rio Blanco County, Colorado. Nine oil and gas fields were extended relatively short distances, and five important dry holes were drilled.

NEW PRODUCING ZONES IN OIL FIELDS

WYOMING

East Mahoney (West Ferris) field.—On March 7, 1940, the Sinclair Wyoming Oil Company discovered about 246 barrels of oil a day in the Tensleep sandstone (Pennsylvanian) in its Government No. 4, SE. ¼, SW. ¼ of Sec. 29, T. 26 N., R. 87 W., Carbon County. The top of the Tensleep was found at a depth of 4,272 feet, and the oil-producing zone at a depth of 4,272–4,293 feet. Water was found at a depth of 4,315 feet. The gravity of the Tensleep oil is 43.5°.

COLORADO

Wilson Creek field.—Drill stem tests of The Texas Company's Government No. 5, NE. ¼, NE. ¼ of Sec. 34, T. 3 N., R. 94 W., Rio Blanco County, in February, 1941, indicated that the well would produce about 700 barrels of 50° gravity oil per day from the Sundance (Upper Jurassic) sand at a depth of 6,544 feet. This well is the first Sundance producer in the field—all earlier wells producing from the superjacent Morrison formation—and was drilled atop the dome about ½ mile northwest of the discovery well in the Morrison formation (Upper Jurassic).

DEEPER PRODUCING ZONES IN OLD FIELDS

WYOMING

Mahoney dome.—The Sinclair Wyoming Oil Company's Government No. 3, SE. ¼, NW. ¼ of Sec. 34, T. 26 N., R. 88 W., Carbon County, which was originally completed as an oil well in the Tensleep sandstone (Pennsylvanian) at a total depth of 4,486 feet in October, 1938, was deepened 19 feet in the fall of 1940 and pumped about 834 barrels of oil a day from the lower zone. This field has yielded relatively large gas wells in the Cloverly formation (Lower Cretaceous) and Sundance formation (Upper Jurassic) since 1919.

Lost Soldier field.—In October, 1940, the Sinclair Wyoming Oil

Company's Well No. 75, SW. ¼, NW. ¼ of Sec. 11, T. 26 N., R. 90 W., Sweetwater County, which has produced relatively large amounts of oil in higher zones of the Tensleep sandstone since it was originally completed in 1930, was drilled to a depth of 4,244 feet in the basal part of the Tensleep, where it yielded 1,577 barrels of oil a day naturally and 2,203 barrels a day on the gas lift. Two other wells in the field that were subsequently deepened to the base of the Tensleep in 1940 yielded smaller amounts of oil.

RECOMPLETIONS

WYOMING

Cole Creek field.—In May, 1940, the General Petroleum Corporation started the development of good oil showings found in the Shannon sandstone member of the Steele shale (Upper Cretaceous) during deeper drilling in 1937 and thereafter. In that month, Government No. 1 well, NW. ¼, NW. ¼ of Sec. 21, T. 35 N., R. 77 W., Natrona County, pumped about 350 barrels of 35° gravity oil from the Shannon sand at a depth of 4,542–4,562 feet, after drilling to a total depth of 8,050 feet in the Morrison formation (Upper Jurassic). Later in the year, eight more oil wells were drilled to the Shannon sand in the field, and one older and deeper well was recompleted in that sand.

EXTENSIONS TO OLD FIELDS

WYOMING-MONTANA

Frannie field.—In September, 1940, the Frannie field, Park County, Wyoming, was extended almost ½ mile northwestward into Carbon County, Montana, by the Continental Oil Company's Prigge No. 1, SE. ¼, SE. ¼ of Sec. 33, T. 9 S., R. 25 E. This well pumped 75–124 barrels of 24.6° gravity oil daily from the Tensleep sandstone (Pennsylvanian) at a depth of 3,522–3,561 feet.

WYOMING

Lance Creek field.—In 1940, oil production in the basal Sundance sand (Upper Jurassic) was extended about ½ mile eastward by two wells drilled in the NW. ¼ of Sec. 36, T. 36 N., R. 65 W., Niobrara County, by the Ohio Oil Company. Well No. 8, NW. ¼, NW. ¼, NW. ¼, was completed for production on April 14 at a total depth of 4,337 feet, having an initial daily production of 1,440 barrels of oil at a depth of 4,327–4,337 feet. Well No. 9, NW. ¼, SW. ¼, NW. ¼, was completed for production on October 29 at a total depth of 4,468 feet, yielding 315 barrels of oil and 15 barrels of water at a depth of 4,411–4,468 feet.

Wertz dome.—Although the Wertz dome has yielded commercial amounts of oil in upper and lower zones of the Tensleep sandstone (Pennsylvanian) since 1936, only one well was drilled in the field during 1940, extending the producing area about ¼ mile northeastward. This well, the Sinclair Wyoming Oil Company's Government No. 14-B, SW. ¼, NE. ¼ of Sec. 7, T. 26 N., R. 89 W., Carbon County, was completed for production in August and yielded initially 6,861 barrels of oil daily from the Tensleep at a depth of 5,740–6,043 feet. Later in the year, several more wells started drilling in the field, and by the middle of January, 1941, one 936-barrel oil well had been completed in the Tensleep.

Muskrat field.—In September, 1940, the Sinclair Wyoming Oil Company's Government No. 2-A, SE. ¼, SW. ¼ of Sec. 34, T. 34 N., R. 92 W., Fremont County, which was drilled that year to a total depth of 5,838 feet in the Sundance formation (Upper Jurassic), was completed for gas production in the first sand of the Frontier formation (Upper Cretaceous) at a depth of 4,170–4,190 feet, the estimated daily production being 40 million cubic feet. This well extends gas production in the Frontier about ½ mile northwestward.

Big Sand Draw field.—In July, 1940, the Sinclair Wyoming Oil Company extended Frontier gas production almost ½ mile southeastward by completing its Government No. 12, SE. ¼, NW. ¼ of Sec. 23, T. 32 N., R. 95 W., Fremont County, at a total depth of 3,828 feet. This well produced initially about 4 million cubic feet of gas daily from the third and fourth sands of the Frontier at the respective depths of 3,370–3,450 feet and 3,540–3,585 feet.

Labarge field.—The present north end of the Labarge field, Sublette County, was extended about ½ mile westward in 1940 by the completion of a number of wells in Secs. 27 and 28, T. 27 N., R. 113 W., being the second most active drilling area in Wyoming that year. The initial daily production of the new wells was as much as 315 barrels each, and the producing zones are sands in the Wasatch group (Eocene) at an average depth of 1,000 feet. In the North Labarge field, 2½ miles north of the Labarge field, one well completed in the summer of 1940 produced about 40 barrels of 46° gravity oil a day from sands in the Wasatch group at depths of 2,012–2,020 feet and 2,027–2,047 feet.

Hiawatha field.—That part of the Hiawatha gas field lying in Sweetwater County probably was extended about one mile north in 1940 by the Vermilion Oil Company's Government No. 1, SW. ¼, SW. ¼ of Sec. 7, T. 12 N., R. 99 W., which was completed for production on December 24, at a total depth of 3,540 feet. The producing zones are lenticular sandstones in the Wasatch formation (Eocene) at

depths of 3,470–3,540 feet, and the initial production was about 8,600,000 cubic feet a day, with a pressure of 1,220 pounds per square inch.

COLORADO

Hiawatha field.—In June, 1940, the Mountain Fuel Supply Company's Government No. 5, SW. ¼, NW. ¼ of Sec. 23, T. 12 N., R. 100 W., Moffat County, was completed on the east side of the Hiawatha gas (initially) field at a total depth of 2,592 feet, yielding initially about 327 barrels of oil a day on the pump. The producing zones are lenticular sandstones in the Wasatch formation (Eocene) at depths of 2,031–2,115, 2,274–2,318, and 2,482–2,512 feet. The gravity of the oil differs in the three producing zones, but is more than 40°. Another oil well completed in August, 1940, in the NW. ¼, SW. ¼ of the same section produced 40 barrels of oil a day initially.

Wilson Creek field.—Oil production in the Morrison formation (Upper Jurassic) was extended ¾ mile southwestward by the completion in November, 1940, of The Texas Company's Government No. 4, Lot 4, Sec. 2, T. 2 N., R. 94 W., Rio Blanco County, at a total depth of 6,698 feet. The Morrison sand was found at the approximate depth of 6,450–6,500 feet. This well flowed 436 barrels of 50° gravity oil in twenty-four hours through a ⅝-inch tubing choke and had a considerably larger flow through open tubing.

The Texas Company's Government No. 3, NE. ¼, NE. ¼ of Sec. 27, T. 3 N., R. 94 W., found only water in the Morrison sand at a depth of 6,265–6,333 feet and was abandoned.

IMPORTANT DRY HOLES

MONTANA

Willshaw Flats.—On the Willshaw Flats structural nose, Toole County, W. M. Hanlon *et al.* No. 1, center of SW. ¼, SE. ¼ of Sec. 6, T. 37 N., R. 1 W., was completed in July, 1940, as a dry hole in the Ellis formation (Upper Jurassic) at a total depth of 2,346 feet. This well was located on the same structural contour that produces oil in the Border-Red Coulee plunging nose 15 miles westward.

Absarokee.—In the last half of 1940, The Texas Company's Unit No. 1, SE. ¼, NW. ¼ of Sec. 10, T. 4 S., R. 19 E., Stillwater County, was drilled to a total depth of 7,116 feet through the Sundance sand (Upper Jurassic) without finding oil or gas in any zone. The well was drilled on a broad, low dome located relatively near several fields that produce oil and gas from several of the formations drilled.

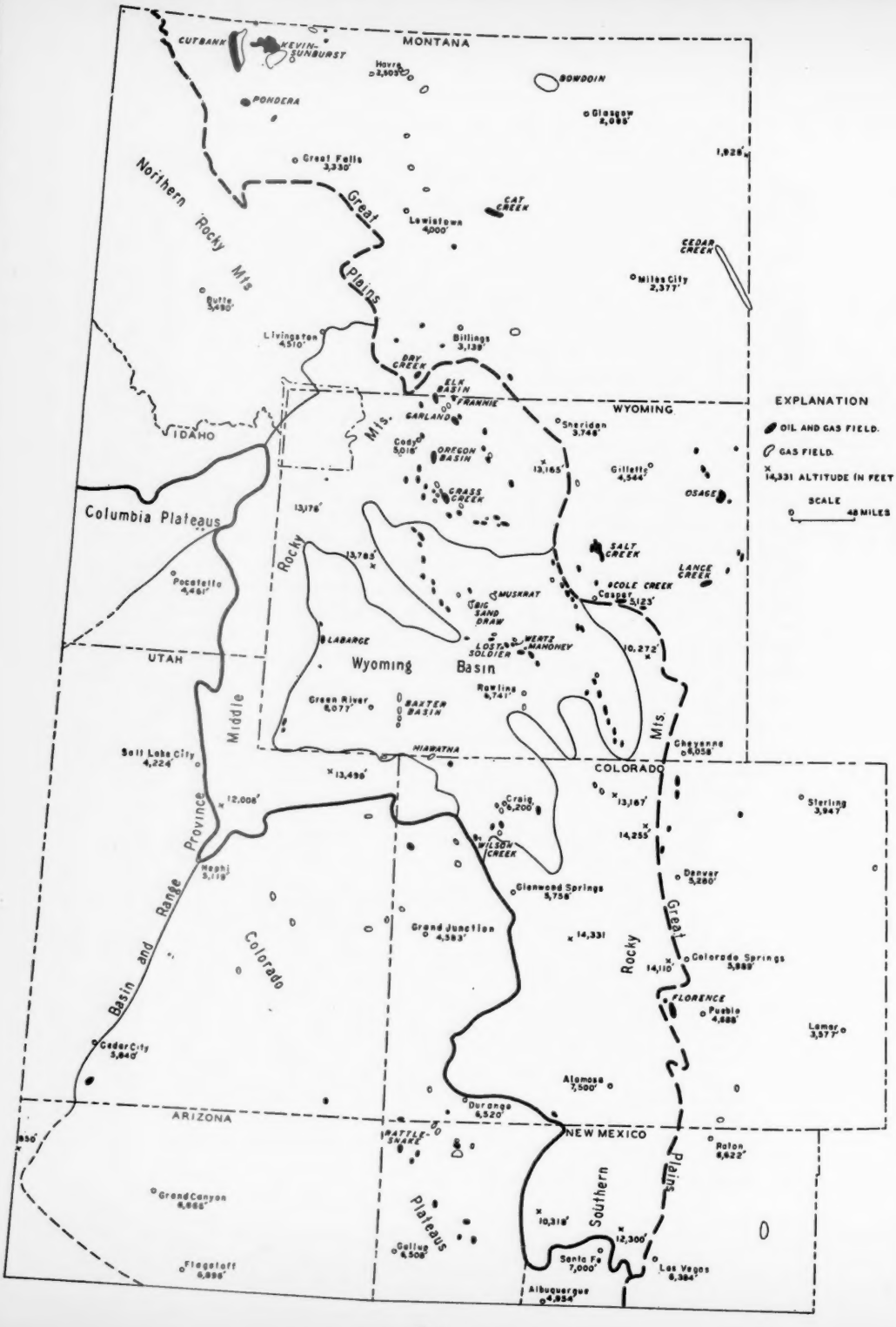

MONTANA
CUTBANK
KEVIN-SUNBURST
Havre 2,503'
BOWDOIN
PONDERA
Glasgow 2,095'
1,928'
Great Falls 3,330'
Northern Rocky Mts.
Great Plains
CAT CREEK
Lewistown 4,000'
CEDAR CREEK
Miles City 2,377'
Butte 5,480'
Livingston 4,510'
Billings 3,138'
BOX CREEK
ELK BASIN
FRANNIE
GARLAND
WYOMING
Sheridan 3,748'
IDAHO
Cody 5,016'
OREGON BASIN
13,165'
Gillette 4,544'
Rocky Mts.
GRASS CREEK
OSAGE
Columbia Plateaus
13,176'
13,785'
SALT CREEK
LANCE CREEK
COLE CREEK
Casper 5,123'
Pocatello 4,481'
MUSKRAT
BIG SAND DRAW
LABARGE
LOST SOLDIER
WERTZ
MAHONEY
10,272'
UTAH
Wyoming Basin
Green River 6,077'
BAXTER BASIN
Rawlins 6,741'
Middle Rocky Mts.
Cheyenne 6,058'
Salt Lake City 4,224'
13,498'
HIAWATHA
COLORADO
12,008'
Craig 6,200'
13,167'
Sterling 3,947'
14,255'
WILSON CREEK
Basin and Range Province
Nephi 5,119'
Glenwood Springs 5,758'
Denver 5,280'
Grand Junction 4,583'
14,331
Great
Colorado
Rocky
14,110'
Colorado Springs 5,989'
FLORENCE
Pueblo 4,686'
Lamar 3,577'
Cedar City 5,840'
Alamosa 7,500'
Durango 6,520'
ARIZONA
NEW MEXICO
RATTLESNAKE
Raton 6,622'
Grand Canyon 6,866'
Plateaus
Southern
Plains
10,318'
12,300'
Gallup 6,508'
Santa Fe 7,000'
Las Vegas 6,384'
Flagstaff 6,896'
Albuquerque 4,954'
EXPLANATION
OIL AND GAS FIELD.
GAS FIELD.
14,331 ALTITUDE IN FEET
SCALE
0 48 MILES

FIG. 1

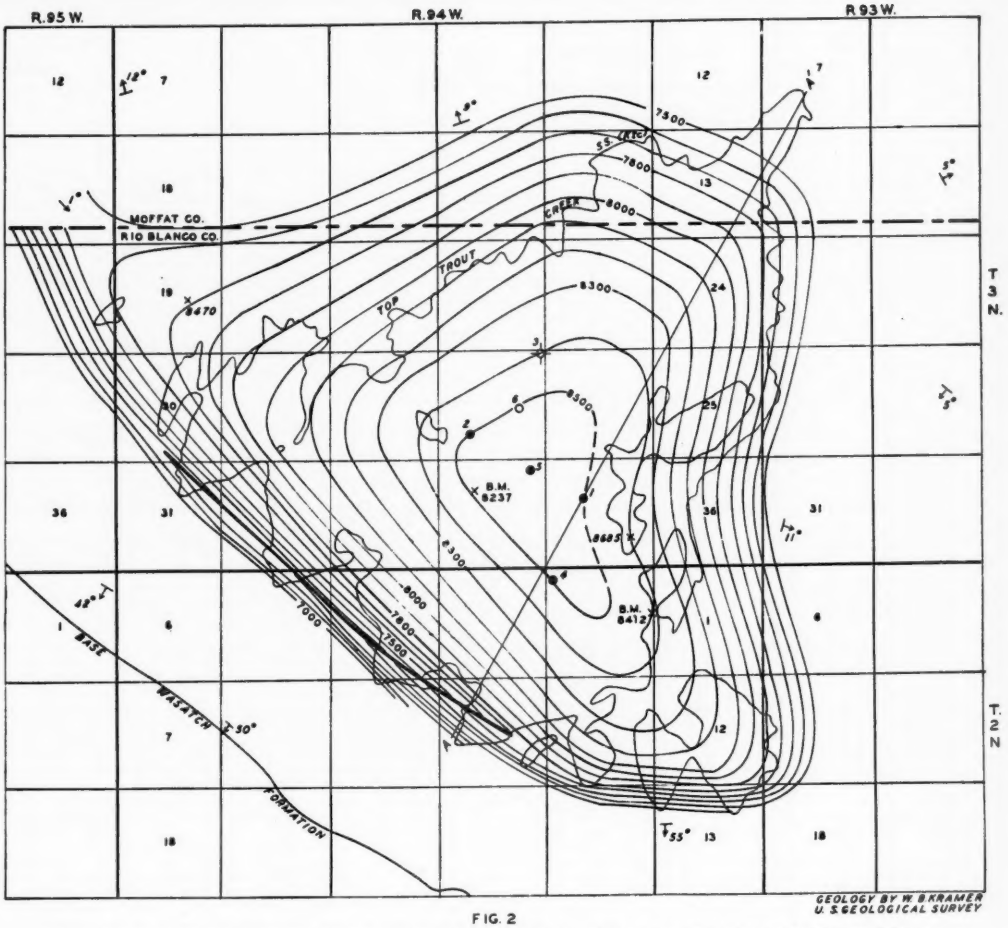
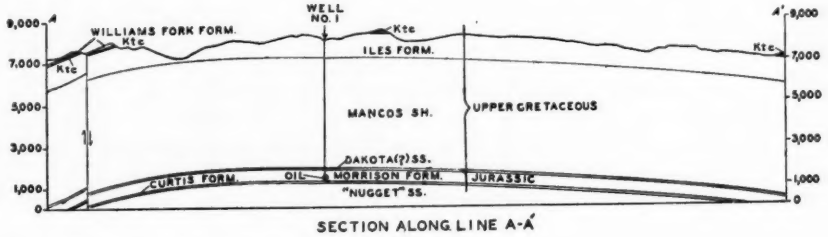


FIG. 2

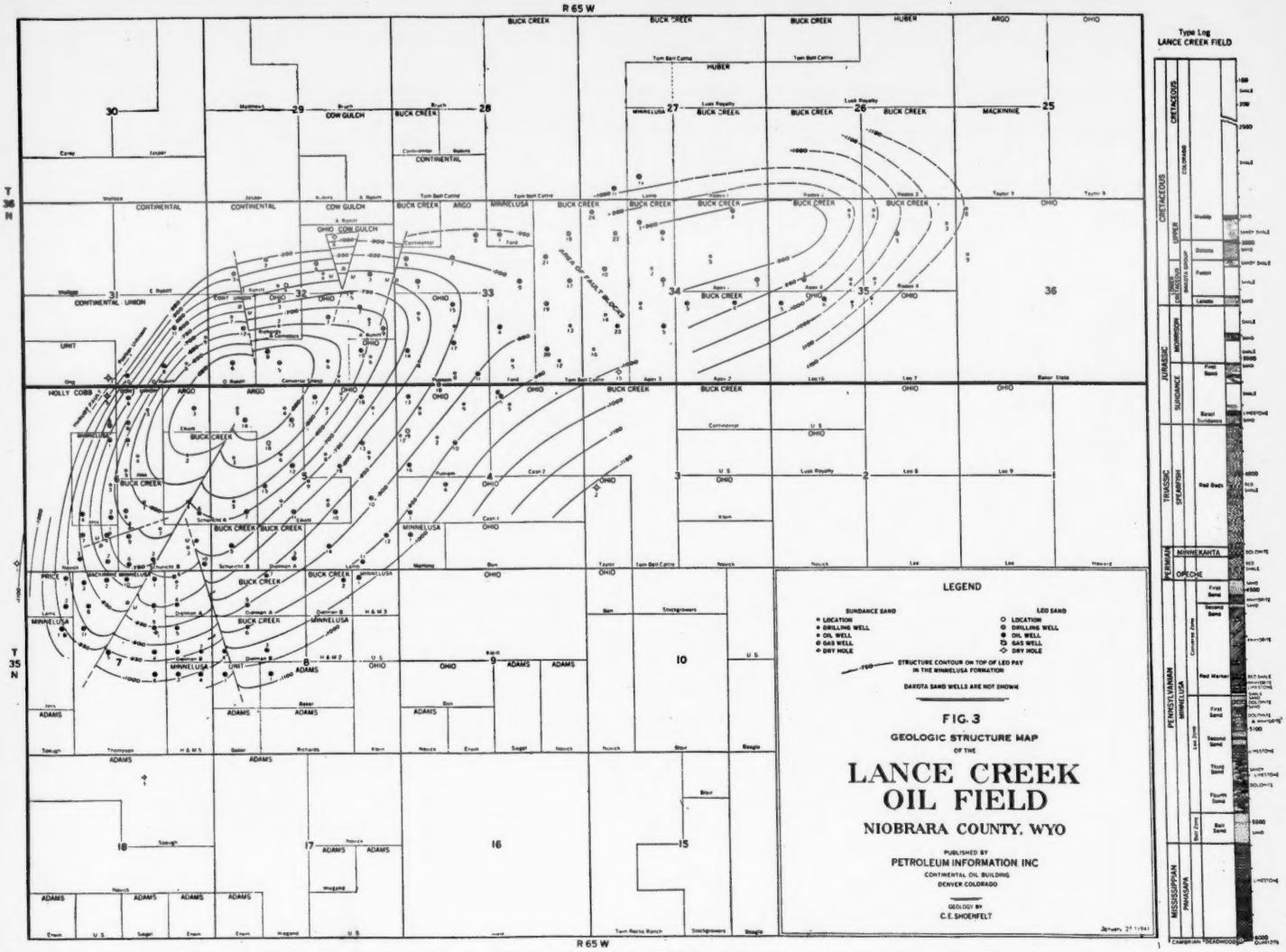
GEOLOGIC MAP OF THE WILSON CREEK DOME, RIO BLANCO AND MOFFAT COUNTIES, COLORADO.

SCALE 0 1 MILE



SECTION ALONG LINE A-A'

FIG. 2


R 65 W
T 36 N
T 35 N
R 65 W
Type Log
LANCE CREEK FIELD
CRETACEOUS
UPPER
COLORADO
MORRISON
SUNDANCE
JURASSIC
TRIPLE
TRIASSIC
SPEARFISH
PERMIAN
MINNEKAHTA
OPECHE
PENNSYLVANIAN
MINNELUSA
MISSISSIPPIAN
PAHASAPA
CAMBRIAN
DEADWOOD
LEGEND
SUNDANCE SAND
LOCATION
DRILLING WELL
OIL WELL
GAS WELL
DRY HOLE
LEO SAND
LOCATION
DRILLING WELL
OIL WELL
GAS WELL
DRY HOLE
STRUCTURE CONTOUR ON TOP OF LEO PAY IN THE MINNELUSA FORMATION
DAKOTA SAND WELLS ARE NOT SHOWN
FIG. 3
GEOLOGIC STRUCTURE MAP
OF THE
LANCE CREEK
OIL FIELD
NIOBRARA COUNTY, WYO
PUBLISHED BY
PETROLEUM INFORMATION INC
CONTINENTAL OIL BUILDING
DENVER COLORADO
GEOLOGY BY
C.E. SHOENFELT
January 21, 1961

WYOMING

Bull Creek.—In July, 1940, the Union Oil Company completed its No. 1, NE. ¼, NW. ¼ of Sec. 3, T. 57 N., R. 62 W., Crook County, as a dry hole in the Deadwood formation (Cambrian) at a total depth of 4,243 feet. The Minnelusa sandstone (Pennsylvanian) which yields prolific amounts of oil in the Lance Creek field, Niobrara County, and is saturated with oil at its outcrop at Rocky Ford, Crook County, was dry. The Deadwood formation contained water.

Middle Baxter Basin.—In November, 1940, the Red Desert Corporation completed its Government No. 1, NW. ¼, NW. ¼ of Sec. 34, T. 18 N., R. 103 W., Sweetwater County, as a dry hole at a total depth of 6,302 feet in Pennsylvanian sandstone, being the first well to test Pennsylvanian beds in the Rock Springs uplift. The Pennsylvanian sandstone was penetrated about 144 feet and yielded only a small showing of oil. Jurassic beds yielded only small amounts of oil, and the Dakota sandstone and Frontier formations, of Upper Cretaceous age, showed some oil saturation. It is reported that the well is poorly located structurally and especially so with respect to the present gas-producing fields along the uplift.

North Geary.—In July, 1940, the Continental Oil Company abandoned its McGrath No. 1, center of NW. ¼, SW. ¼ of Sec. 15, T. 34 N., R. 78 W., Natrona County, at a total depth of 8,343 feet in the Tensleep sandstone (Pennsylvanian). The Sundance sand (Upper Jurassic)—the original drilling objective—was dry, and no other zones showed encouraging amounts of oil or gas.

PIPE LINES

In Wyoming in 1940, the Cole Creek oil field, Natrona County, was connected to the White Eagle refinery near Casper by 13 miles of 4-inch pipe; the Sinclair Wyoming Oil Company laid 27.7 miles of 8-inch pipe near Casper, connecting its Salt Creek-Parco trunk line with the Stanolind Pipe Line Company's 715-mile line to Freeman, Missouri; the Northern Pipe Line Company laid a 100-mile pipe line between Casper and the Billy Creek gas field, Johnson County; the Sinclair Refining Company is constructing about 28 miles of 8-inch pipe line from the Wertz field to connect with the Salt Creek-Parco trunk line; and a 4-inch welded pipe line was constructed northwest of Granger to transport oil from the Labarge field via Opal to the Utah Oil Refining Company's trunk line between Fort Laramie and Salt Lake City, Utah.

In Montana, The Montana Dakota Utilities Company is constructing about 105 miles of 8-inch gas line between Glendive and

Fort Peck, and in Colorado, The Texas Company in 1940 laid 18 miles of 4-inch pipe line from the Wilson Creek field to the Iles field, where it connects with another line leading to a refinery at Craig, the total length of both lines being 37 miles.

NEW DRILLING DEPTH RECORD

WYOMING

A new drilling depth record in Wyoming was established in the summer of 1940, when the Resolute Oil Corporation's State well No. 2 in the Badger Basin field, Park County, suspended drilling at a depth of 10,121 feet in the Morrison formation (Upper Jurassic), without finding commercial amounts of oil or gas below the oil-producing Frontier formation (Upper Cretaceous).

OIL PRODUCTION*

State	*1938*	*1939*	*1940*
Colorado	1,324,374	1,401,199	1,401,577
Montana	4,824,917	5,854,116	6,580,745
NW. New Mexico	344,637	302,550	254,048
Wyoming	18,956,277	21,492,187	26,132,076
	25,450,205	29,050,052	34,368,446

* Production figures from the *Oil and Gas Journal*.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1159-1166, 1 FIG.

CALIFORNIA EXPLORATION AND DEVELOPMENT IN 1940[1]

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ABSTRACT

The discovery rate for the year 1940 in California declined. This followed and was accompanied by a decrease in geophysical work and exploratory drilling while geological employment remained approximately the same. Only one new oil field was discovered and there were a few areal and depth extensions of known fields. Several wildcat wells were completed as small producers in what, at present, appear to be noncommercial accumulations.

Drilling within fields increased California's production potential but additions to reserves has lagged behind withdrawals and lowering of estimates in fields under development. Faster drilling has accelerated the approach to a drilled-up status for California fields. An attempt is made to arrive at the cost and length of pay-out time for an average top allowable well as an indication of the optimum expectancy for operating capital put into development wells.

Methods of attack now being used on the California exploration problem are referred to briefly.

GENERAL

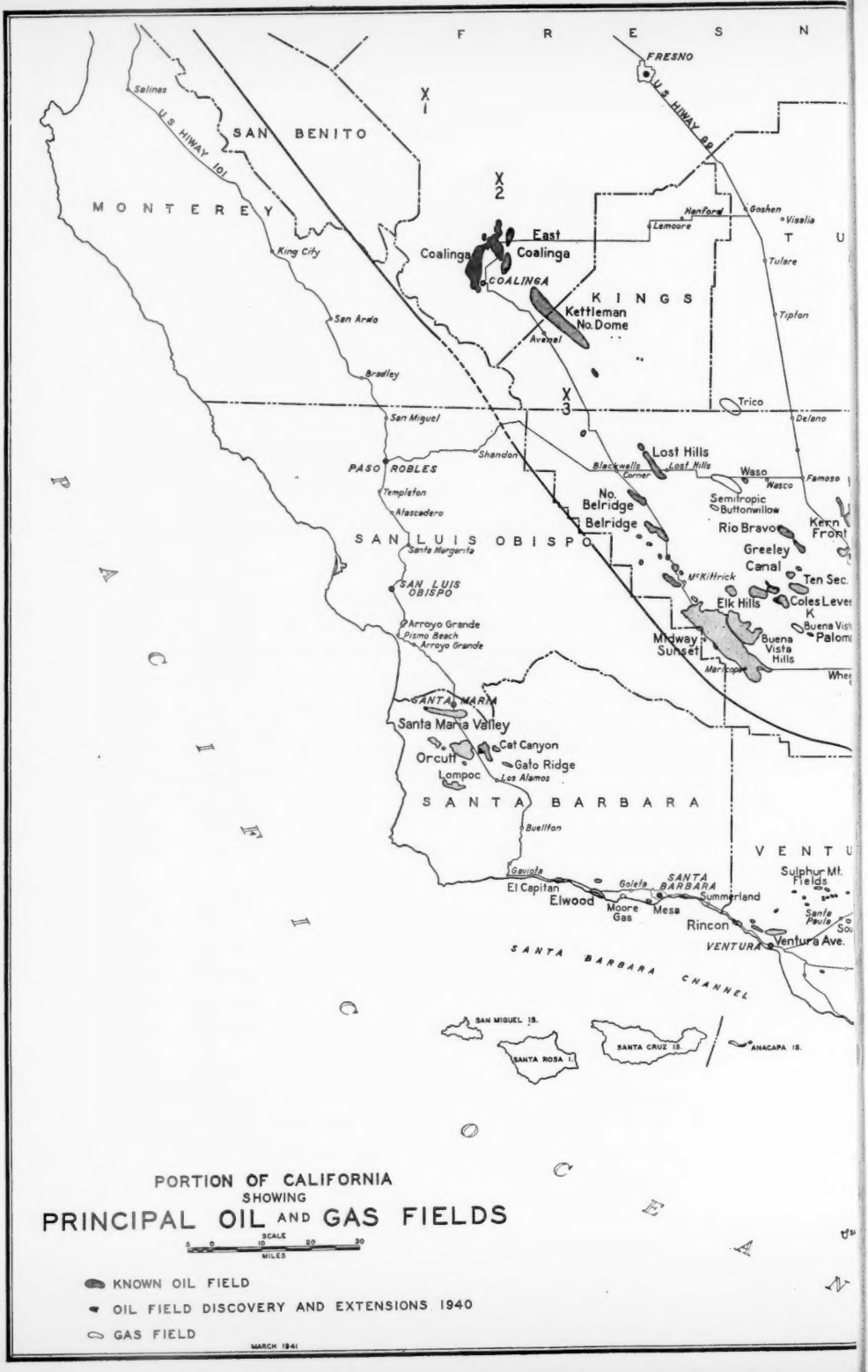
The cycle of discovery in California for the year 1940 continued its descent from a 1936–1937 peak to the lowest point since 1933. This seems to fulfill the prophecy indicated by the trend of diminishing exploration activity which began in 1938. There was a marked slowing down in geophysical activity as shown by the decline from 25 parties employed at the beginning of the year to 16 at the end of the year. Holes properly classed as wildcats number 78 in 1940 compared with 91 in 1939. Geological effort, as measured by employment, remained approximately at the level of 1939, although because of decreased number of wells drilled, it is reasonable to conclude that more geologists were directly engaged in field mapping and subsurface studies than during the previous year.

Del Valle field in the Castaic area of Los Angeles County was the only new discovery of commercial proportions in 1940 although several wildcat wells found oil indications which at present appear to be noncommercial. Deeper productive zones were demonstrated in three proved fields but their significance was not established during the year. Areal extensions of known producing areas were found chiefly in the course of routine development.

Fewer producers were completed in 1940, but as the average well was deeper, the total footage drilled was greater than in 1939. The 859 new oil producers and 240 recompleted wells were sufficient to

[1] Read before the Association at Houston, April 4, 1941. Manuscript received, March 31, 1941.

[2] Continental Oil Company.



PORTION OF CALIFORNIA
SHOWING

PRINCIPAL OIL AND GAS FIELDS

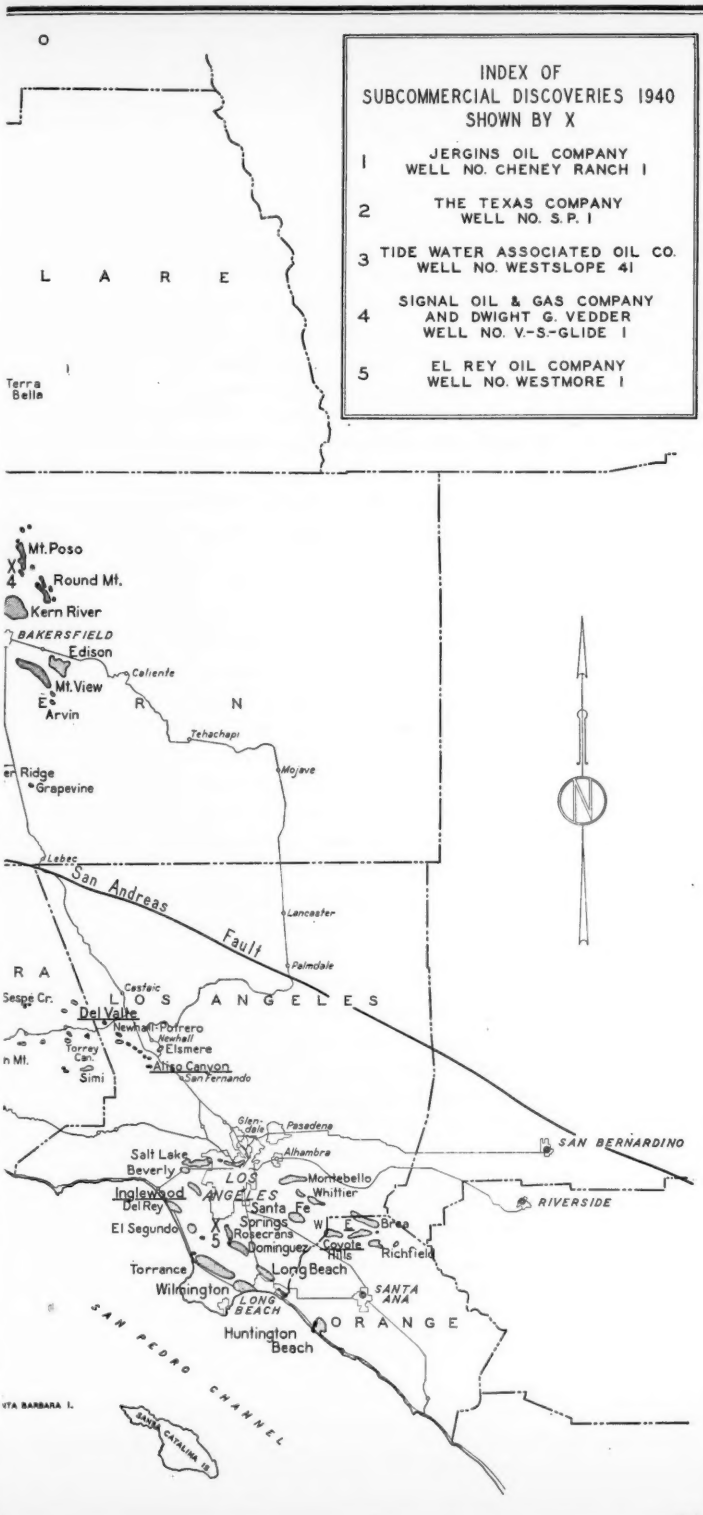
SCALE
0 5 10 20 30
MILES

KNOWN OIL FIELD

OIL FIELD DISCOVERY AND EXTENSIONS 1940

GAS FIELD

MARCH 1941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SUBCOMMERCIAL DISCOVERIES 1940
SHOWN BY X
1 JERGINS OIL COMPANY
WELL NO. CHENEY RANCH 1
2 THE TEXAS COMPANY
WELL NO. S. P. 1
3 TIDE WATER ASSOCIATED OIL CO.
WELL NO. WESTSLOPE 41
4 SIGNAL OIL & GAS COMPANY
AND DWIGHT G. VEDDER
WELL NO. V.-S.-GLIDE 1
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L A R E
Terra Bella
Mt. Poso
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Kern River
BAKERSFIELD
Edison
Caliente
Mt. View
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Tehachapi
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Ridge
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Lebec
San Andreas Fault
Lancaster
Palmdale
Castaic
Sespe Cr.
LOS ANGELES
Del Valle
Newhall-Potrero
Newhall
Elsmere
Torrey Can.
Simi
Mt.
Aliso Canyon
San Fernando
Glendale
Pasadena
Alhambra
SAN BERNARDINO
Salt Lake
Beverly
Montebello
Whittier
Inglewood
Del Rey
Santa Fe Springs
RIVERSIDE
El Segundo
Rosecrans
Dominguez
Coyote Hills
Brea
Richfield
Torrance
Long Beach
Wilmington
LONG BEACH
SANTA ANA
ORANGE
Huntington Beach
SAN PEDRO CHANNEL
SANTA BARBARA I.
SANTA CATALINA I.
N

maintain the rapid increase in California's capacity for daily production, which began in 1936. Voluntary curtailment continued to gain in effectiveness. Withdrawal from storage of 7 million barrels of fuel oil during the year resulted in 6,500,000 barrels net decrease of total petroleum stocks in the state. The top allowable production for wells was lowered from 195 barrels per day at the beginning of 1940 to 148 barrels per day in January, 1941. Although California's capacity for daily production increased, estimated reserves added by discovery and extension of producing areas are considerably less than the combination of 224 million barrels of oil produced and reduction of reserve estimates found necessary for certain old fields such as Kettlemen Hills.

Accompanying the notable saving in drilling costs on California wells for which the incentive has been largely furnished by the necessity of curtailing production, the paradox has developed of lowered well allotment, causing wells to be drilled faster to save expense. When applied to lease contracts the time thus saved causes more wells to be drilled in a given period and eventually results in a further reduction in well allotment. This vicious spiral may not continue much longer, however, for the drilling speed-up has hastened definition of areal limits in many of the important top-allotment fields now under development. This indicates that much of the more prolific proved acreage in the state is rapidly approaching a drilled-up status and thus forecasts a decline in California's capacity for daily production in the not too distant future. It also implies that exploratory efforts must be stepped up if the state is to maintain its position as an oil producer.

An attempt made to estimate the cost of drilling and completing a well representative of average operating conditions in the so-called top-allowable fields resulted in a figure of very close to $90,000 for 1940. Length of pay-out time for such a well, based on current and estimated future top well allotments and present prices for oil in the various fields, should be close to 30 months or 2½ years. This may be taken as representative of the best average experience an operator investing in development wells has a right to expect in California. As already mentioned drilling costs are being reduced, but so is the top-allotment, hence there is no particular reason to hope for a very marked shortening of the pay-out period in the near future.

DISCOVERIES

Del Valle field.[3]—The development of greatest economic significance during 1940 was the discovery by R. E. Havenstrite of Del Valle oil

[3] R. W. Sherman, "Del Valle Oil Field, Los Angeles County, California." Presented before the American Association of Petroleum Geologists, Houston, April 4, 1941.

field, 3 miles west of Castaic Junction on the north side of Santa Clara River near the western edge of Los Angeles County (Fig. 1). It lies in the eastern part of the geological province known to many as the Ventura basin. The discovery well, Lincoln No. 1, Sec. 16, T. 4 N., R. 17 W., S.B.B. & M., was originally completed in September, 1940. With bottom at 6,954 feet and with about 220 feet of sandy formation open, it produced 300 barrels of 58° gravity oil and 10 million cubic feet of gas per day. Recompletion in October, to lower the gas-oil ratio, gave a rate of 875 barrels of 33° oil and 280,000 cubic feet of gas per day. Production is coming from sands in upper Miocene. There has not yet been enough development to give a very definite idea as to the field's extent. Its chief significance at present is that of inspiring intensive wildcat drilling in the vicinity during 1941.

Aliso Canyon deeper zone.—Tide Water Associated Oil Company demonstrated a deeper high gas-oil ratio producing zone for Aliso Canyon field (Fig. 1) when it plugged back its Porter No. 12 well from 8,202 feet to 7,551 feet and completed it for 201 barrels of 53° gravity oil and 12,628,000 cubic feet of gas per day. Approximately 640 feet of Topango formation (middle Miocene) are open to production of which less than 200 feet of sands contribute most of the oil and gas. Little is known about this zone because none of the later wells have drilled into it.

Inglewood deeper zone.[4]—R. R. Bush Oil Company discovered Miocene production near the southeast edge of the known producing area of Inglewood field (Fig. 1). It completed its Sentous No. 1 well with bottom at 8,760 feet for a settled rate of 80 barrels of 30° gravity oil and 100,000 cubic feet of gas per day. The producing formation is considered to be Topango (middle Miocene) because *Valvulineria californica* is found in abundance. The oil sands thought to be capable of producing comprise less than 20 per cent of the 435-foot interval open in the well. A recent completion in this same zone at the northwest end of the Pliocene field establishes it as of commercial importance in Inglewood field and points the way for further prospecting to these sands in other fields of Los Angeles Basin.

East Coyote deeper zone.—Bartholomae Oil Corporation deepened its Stern No. 1 well, near the west end of East Coyote field (Fig. 1) to 5,952 feet and demonstrated another productive zone for this field in sediments that are probably upper Miocene in age. Six wells had been successfully completed in this zone by the end of 1940.

[4] A. F. Woodward, "Recently Discovered Miocene Production in the Inglewood Oil Field, California." Presented by title before the American Association of Petroleum Geologists, Houston, April 4, 1941.

It appears that production in the zone may extend toward the east and be of importance under the main part of the field.

SUBCOMMERCIAL DISCOVERIES

One of the most interesting wildcat projects of 1940 was that initiated by Jergins Oil Company in the Panoche Creek area of Fresno County on the west side of San Joaquin Valley (loc. 1, Fig. 1). The play and location of test well Cheney Ranch No. 1, Sec. 29, T. 14 S., R. 13 E., M.D.B. & M., was based on a soil-analysis survey. In spite of adverse mechanical conditions the well developed a small quantity of gas and distillate production from sands in the lower part of the Moreno shale (Upper Cretaceous). A follow-up well, which is now being tested, indicates a somewhat increased amount of gas and distillate production not yet of commercial proportions. This project is of significance because it is about 30 miles northwest of the present known oil-producing province of San Joaquin Valley and indicates Cretaceous oil possibilities in the central part of the state which heretofore have received relatively little attention in exploration work.

The Texas Company completed a wildcat, S. P. 1, Sec. 23, T. 17 S., R. 15 E., M.D.B. & M. (loc. 2, Fig. 1) as a small producer of distillate and gas accompanied by salt water. This well is on the Turk anticline in Cantua Creek area of Fresno County where there has been considerable wildcat drilling in recent years. The zone carrying the oil is a sand in Eocene. A second well southeast missed the sand from which the first produced and a third is now drilling to the northeast.

Tide Water Associated Oil Company developed 20 barrels per day of 16° gravity oil from a depth of 950 feet in the course of drilling several core holes to explore an overlap play on the McClure Valley side of Pyramid Hills in Kings County (loc. 3, Fig. 1). The producing well is in Sec. 20, T. 24 S., R. 18 E., M.D.B. & M. The oil sands are believed to be in lower Oligocene or upper Eocene. Subsequent drilling has so far offered little encouragement for developing a very large producing area.

Signal Oil and Gas Company completed a well for approximately 120 barrels of oil per day from 2,314 feet in the Glide area southwest of Mount Poso field in Kern County (loc. 4, Fig. 1). Shortly after completion, water trouble developed which has not yet been remedied. The oil is found in the Vedder sand (lower Miocene).

In Los Angeles Basin between the Athens and Potrero fields, El Rey Oil Company developed 40–60 barrels of 30° gravity oil per day from a depth of 9,000 feet (loc. 5, Fig. 1). The oil is coming from thin streaks of tight Miocene sands thought to be equivalent to the

Seventh Callender zone at Dominguez. The depth of this tight zone will probably discourage further drilling in this area for the time being.

AREAL EXTENSIONS

Extensions of the producing area took place in many fields and were in most cases the result of normal development. In Los Angeles Basin expansion of Dominguez, Huntington Beach, and Rosecrans took place. In the Coastal district Aliso Canyon, Newhall Potrero, Santa Maria Valley, and West Cat Canyon continued to grow. In San Joaquin Valley the Coalinga Eocene fields, North and South Coles Levee, Greeley, western Midway, Paloma, and Rio Bravo were all extended in one or more directions.

Extension during the year of Paloma field in Kern County by four wells seems to justify the prediction made last year by Atwill[5] that it appears to have major potentialities. It is the first field in California to be classified as a distillate producer and plans are now under way for the installation of gas-cycling equipment.

Structural control obtained in 1940 in the North Coles Levee (originally called Richfield Western) and the South Coles Levee fields now definitely indicates they are two separate anticlinal structures and that their consolidation and classification as one field, after being credited as separate discoveries in 1938, might again be reconsidered. However, it appears in addition to the evidence for anticlinal accumulation that stratigraphic and lithologic variations are important factors for the accumulation of oil in some of the sands in these fields.

CALIFORNIA EXPLORATION PROBLEM

It seems rather apparent to those concerned with the future of exploration for oil in California that the 1940 discovery experience may be taken as both a challenge and a prophecy. Hoots[6] recognized the beginning of a declining discovery cycle by the end of 1938 and correlated it with a decrease in prospecting activity caused by misinterpretation of overproduction economics. It is undoubtedly true that if well allotments were higher or the price of oil better more money would be spent on exploration activity, and the reasonable supposition follows that some more oil would thus be found. There are, however, certain indications that a change of strategy and a reappraisal of work already completed is as necessary as stepping up the application of

[5] E. R. Atwill, "Significant Developments in California, 1939," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 6 (June, 1940), p. 1113.

[6] Harold W. Hoots, "Additions to Oil Reserves in California during 1938," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 6 (June, 1939), p. 945.

methods recently successful. The very fact that so many wildcat wells located accumulation of oil apparently of subcommercial proportions suggests a measure of careful geological discrimination, but it also illustrates the marginal type of play currently being drilled in the state. There is much seismograph work yet to be done but the job for which seismograph is best adapted, that of locating buried anticlinal structure, is nearly complete in the recognized oil-producing provinces of the state. Future seismograph work will have to be more closely and carefully executed with full use of all possible velocity control. Methods for the better recognition of faults and pinch-out conditions are receiving increasing attention in all forms of geophysical exploration. Experience gained from recent wildcat holes, particularly some very deep and costly ones, emphasizes the serious need for a better understanding of how reservoir characteristics of sand are developed and what, if anything, might be done to estimate sand conditions to be expected in a given formation at the probable depth for the location in question. Toward this end more intensive work is being done on stratigraphic problems, with increased attention to sedimentary processes and types of lithologic change, both in field mapping and subsurface work. The California exploration problem becomes more challenging as the state's reserves are reduced, but it can be solved by increasing effort and improving the technique of search and recognition.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude for the coöperative manner in which his questions and requests for data were answered by many geologists and oil companies. He is especially indebted to his associates and friends for their helpful advice and criticism, particularly E. B. Noble, R. M. Barnes, H. W. Hoots, and C. H. Green, and also W. G. Martin for preparing the map.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1167-1174

WHY CRUDES DIFFER IN VALUE[1]

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ABSTRACT

Although crudes are all fundamentally made up of mixtures of hydrocarbons and are hence similar in this respect, the type of hydrocarbons and the relative proportions in which they are present can vary widely from crude to crude. This variation causes crudes to differ in value. This value is established by the refineries which use crudes as a raw material for the manufacture of the various finished products. Some crudes are in demand and are assigned a high value because substantial yields of good quality products can be made from them with little special processing, whereas others are penalized because certain products are not present or are of such poor quality that special processing (which is usually expensive) is necessary to make these products saleable. In order to evaluate crude, a sample is assayed in the laboratory, whereby the yield and quality of the primary products are determined and these data are used in computing the value of the crude. Other factors, such as transportation costs to refinery centers and the ultimate consumers and competitive conditions, are also considered in arriving at the price paid for a crude at the well.

Until 20 or 25 years ago all petroleum products were "straight-run" and refining was essentially a process for separating the products in the crude, one from another, and removing impurities. Since then numerous refining processes have been developed that produce such decided chemical and physical changes that the finished products differ radically from the components of the crude used as the raw material for these processes. As they permitted the refiner to make a product of good quality from a poor or an indifferent crude, it was believed some years ago that "after all, a barrel of crude is a barrel of crude," hence, that all crudes should have substantially equal values, at least when corrected for differences in gravity. This, however, is not true, for, in spite of the newer processing methods, crudes do differ in value, and this in turn is largely responsible for the variations in the prices for different crudes.

Actually, no two crudes are exactly alike. This is not surprising when we understand that crudes are mixtures of countless, different hydrocarbons and in no two crudes are the proportions the same. Not only do these hydrocarbons belong to different general types, such as the paraffine, the naphthene, and the aromatic series but in each series there exists a tremendous number of individual compounds. The presence or absence of compounds in any series in substantial amount can materially affect the quality of the products obtained. Thus, for example, the aromatics have high octane numbers (good anti-knock characteristics), and consequently if a crude contains substantial

[1] Read before the Association at Houston, April 3, 1941. Manuscript received, April 14, 1941.

[2] Humble Oil and Refining Company.

amounts of aromatics in the gasoline boiling range the gasoline produced will have a high octane number, whereas a crude containing predominantly normal paraffines will have a low octane number. But even in a given series the various hydrocarbons possess widely different properties and characteristics. There are, for example, nine heptanes all having the formula C_7H_{16} but differing from one another in the relative arrangement of the carbon and hydrogen atoms in the molecule. In most respects, such as density, boiling point, and refractive index, they are quite similar, but in anti-knock quality they show extreme variation. Normal heptane, in which the carbons are strung out in a single straight line or chain, has an octane number rating of zero, whereas one of the remaining eight (specifically known as 2,2,3-trimethylbutane) with a highly branched carbon chain, has an octane number rating of about 110 to 115. The other seven heptanes have octane numbers ranging from 55 to 98. It is differences such as these that account for the fact that, although two crudes may be composed essentially of paraffine hydrocarbons, one can produce a gasoline with an octane number rating of 40, whereas the other produces one with a rating of 70. In the gasoline boiling range, the first crude has more straight chain and less branched chain paraffine hydrocarbons than the second.

Similar differences in quality for the kerosene, gas oil, lubricating oil, and asphalt products can be illustrated, but for the sake of brevity they are not brought into this discussion.

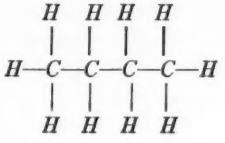
An interesting analogy can be drawn between crude oil and a refinery on the one hand and timber and a sawmill or paper mill on the other. The raw material comes to the sawmill in the form of logs but no one would attempt to claim that the logs are equal in value. Some are soft woods, such as white pine, yellow pine, fir, cypress, cedar, and gum, whereas, others are hard woods, such as oak, maple, hickory, and walnut. Each is best suited for the manufacture of certain products and their values differ accordingly. Flooring can be made from pine, oak, or maple, but the maple flooring is more valuable than the oak which, in turn, is more valuable than the pine. Some pine is entirely unsuited for flooring because of coarseness of grain or presence of knots and is suitable only for cheap low-grade ship-lap. Certain products, such as shingles, can be made only from certain woods.

Since a sawmill merely cuts and dresses the material in the logs but does not change the wood chemically or structurally, this analogy is closer to a refinery that is a skimming plant not using cracking or other modern processes that bring about chemical changes. A paper mill, however, does involve chemical processes and changes the nature of the material during the course of manufacture. This may tend

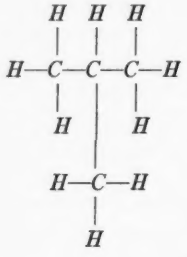
to iron out differences in timber values but even here we find that spruce and certain other soft woods are better raw material than the pines for high-grade papers, whereas, the pines are suitable for the cheaper kraft papers. It is true that recently processes have been developed for making high-grade paper from low-grade wood, but here the processes are more expensive than those previously used, hence, the value of loblolly and other poor-quality pines has increased but little, if any.

And so it is with petroleum. Some crudes produce a good grade of gasoline upon simple distillation; others will produce a good gasoline only if cracking is used and still others will produce a good gasoline only with the greatest difficulty even if cracking is used. Some crudes are sources of aviation gasoline, whereas others are not. Some crudes with simple processing yield lubricating oils that are inherently of good quality, whereas others require extensive and expensive processing for the production of good lubricating oils and still others are entirely unsuited for the production of lubricating oil regardless of the amount or type of processing used.

Since the value of a crude is controlled by its composition or make-up, it may seem that the proper way to arrive at its value is to make a complete chemical analysis to determine which hydrocarbon compounds are absent and which compounds are present and in what amount. The difficulty with this procedure is the enormous number of different compounds present and the lack to date of a simple and rapid technique for separating and identifying the individual compounds. A fundamental research study on the separation and identification of the hycrocarbons present in a petroleum crude, sponsored by the A.P.I., has been in progress at the Bureau of Standards more than 10 years and has cost in excess of $200,000. All of this time has been spent on studying a single crude and the results are still far from complete. The following table shows the number of isomers possible in the paraffine hydrocarbons for some of the formulas. Hydrocarbon isomers are compounds that have the same number of carbon and hydrogen atoms in the molecule (and formula) but differ in the arrangement of these atoms in the molecule. Thus both normal butane and isobutane are isomers, each having four carbon and ten hydrogen atoms in the molecule but the former has the carbons in a straight chain,



whereas the latter has them in the form of a branched chain,



Formula	*Number of Isomers*
C_4H_{10}	2
C_5H_{12}	3
C_7H_{16}	9
C_8H_{18}	18
$C_{10}H_{22}$	75
$C_{15}H_{32}$	4,347
$C_{20}H_{42}$	366,319
$C_{25}H_{52}$	36,797,588
$C_{30}H_{62}$	4,111,846,763
$C_{40}H_{82}$	62,491,178,805,831

This represents the paraffine series only. Similarly large numbers are also obtained for the aromatic and naphthene series. Obviously, a complete chemical analysis is not the answer.

The procedure generally used is to subject a sample of a few gallons of the crude to a crude assay or proximate analysis in the laboratory. The sample is charged to a laboratory still equipped with a fractionating column and separated by distillation into a large number of small (usually 2-5 per cent) well fractionated distillate cuts. The early part of the distillation is carried out under pressure (in order to condense the light components in the crude), the middle part under atmospheric pressure and the last part under vacuum with steam as an aid to distillation. The distillation is carried to the point where the residuum in the still is equivalent to a heavy fuel oil or pitch. In many laboratories the distillation equipment is built according to strict specifications and a carefully controlled procedure is followed in order to achieve uniformity and reproducibility of results, not only within the same laboratory but also between laboratories. These cuts are blended together to meet the dominant specification of the various products, for example, end point for gasoline, boiling range and gravity for kerosene, gravity for Diesel fuels, and viscosity for lubricating oil. These blends are then subjected to the customary laboratory tests for quality. From the crude assays the yield and quality of the various products obtainable from the crude by simple distillation, the "straight-run" products,

TABLE I

QUALITY OF PRODUCTS OBTAINABLE FROM VARIOUS CRUDES

Crude	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*
Gravity, deg. A.P.I.	25.0	28.5	37.0	29.5	32.5	22.0	12.5	42.5	39.0	36.5	41.0	43.0
Normal prime-cut naphtha:												
Yield, per cent[a]	10.0	15.0	31.0	22.0	28.0	12.0	6.0	30.0	33.0	29.0	33.0	32.0
Octane No., C.F.R.-M.M.	72.0	62.0	60.5	61.0	54.0	50.0	56.0	48.0	58.0	50.0	50.0	45.0
Aviation gasoline:												
Yield, per cent[a]	2.0	4.0	10.0	6.5								
Octane No., C.F.R.-M.M.		74.0	73.0	74.0								
Suitability	Yield too low	Good	Fair	Good								
Kerosene or tractor fuel:												
Yield, per cent[a]	26.0[b]	16.0		21.0	21.0	13.0		42.0	23.0	21.0	19.0	23.0
Gravity, deg. A.P.I.	35.0	39.0		40.0	40.6	42.8		43.9	42.2	43.8	44.4	47.2
Sulphur content, per cent	0.06	0.10		0.50	0.46	0.31		0.03	0.04	0.10	0.14	0.04
Sourness	Sweet	Sweet		Very sour	Very sour	Sweet		Sweet	Sweet	Sweet	Sour	Sweet
Thermoviscosity				380	370	380		390	380	360	360	350
Smoke point, I.P.T.					20.0			23.0	21.0	24.0	24.0	30.0
Octane No., C.F.R.-M.M.	65.0	53.0										
Suitability	Good	Fair	Require solvent extraction			Satisfactory except for sulphur		Good	Fair	Good	Satisfactory except for color and sulphur	Very good
Diesel fuel:												
Yield, per cent[a,c]	50.0	29.0	32.0	20.0	19.0	14.0	10.0	41.0	19.0	18.0	17.0	20.0
Gravity, deg. A.P.I.	26.0	29.0	33.0	34.0	35.0	37.0	30.0	39.0	37.0	38.0	40.0	42.0
Sulphur content, per cent	0.18	0.23	0.04	0.8	0.8	0.7	2.2	0.06	0.07	0.20	0.23	0.05
Pour point, deg. F	−60	−60	−10	−25	−15	−5		0	0	0	0	5
Diesel index	30.0	35.0	46.0	46.0	49.0	56.0	36.0	65.0	59.0	60.0	65.0	72.0
Suitability	Very low grade	Poor but low pour	Fair Diesel index and fairly low pour			Good	Sulphur high	Good quality although somewhat waxy			Good quality but sour	Excellent quality somewhat waxy
Lubricating-oil distillates:												
S.U.V. at 100°F.	1000	1000	500	500	500	500			500	500	500	500
Gravity, deg. A.P.I.	17.0	20.0	24.0	22.0	22.0	23.0			25.0	25.0	28.0	30.0
Pour point, deg. F		0	110	25	90	110			115	100	115	100
Sulphur content, per cent	0.23	0.42	0.25	1.7	1.9	2.9			0.56	0.80	0.75	0.15
Vicosity index (after dewaxing to 0°F. pour point)	−60	15.0	50.0	45.0	50.0	55.0			55.0	60.0	80.0	95.0
Suitability	Unsatisfactory	Good L.C.T. and black oils	Unsatisfactory "paraffinic"	High pour for L.C.T. oils	Unsatisfactory "paraffinic"	Low quality "paraffinic"	Unsatisfactory	Low quality "paraffinic"	Low quality "paraffinic"	Fair quality "paraffinic"	Good quality "paraffinic"	Excellent quality "paraffinic"
Asphalts:												
Yield, per cent[d]		5.0	Negligible	11.0	11.0	40.0	65.0	Negligible		7.0	<5.0	Very low
Temperature susceptibility				Fair	Fair	Good	Good			Fair		
Ductility at low temperature				Fair	Fair	Poor	Good			Fair		
Wax content				Satisfactory	Satisfactory	High	Low		Very high	Satisfactory		
Emulsifying characteristics				Poor	Poor	Satisfactory	Excellent			Fair		
Foaming characteristics				Poor	Poor	Poor	Excellent			Fair		
Weathering characteristics				Fair	Fair	Good	Good			Good		
Stain test				Poor	Poor	Poor	Excellent			Good		
Softening point-penetration relationship				Satisfactory	Satisfactory	Satisfactory	Requires blending			Satisfactory		

[a] Normal maximum yield of indicated product. Since the naphtha, tractor fuel or refined oil and Diesel fuel overlap each other consecutive cuts are appreciably less than indicated.

[b] When cutting tractor fuel of 500°F. final boiling point. Refined oil cuts are of 530°F. final boiling point.

[c] Of 650°F. final boiling point and 35 Saybolt universal viscosity at 100°F.

[d] Based on approximately 115°F. softening point asphalt.

are determined. Table I, taken from Beiswenger's paper[3], gives the results of assays on a number of typical crudes. Not all of the data obtained from the assay are included in this table but only those that are particularly significant in determining the quality of the products. It will be noted that the sum of the percentages given for any crude is greater than 100. As pointed out in the footnote, this is because the percentages shown are for the maximum yields of each product and due to overlapping, the yield of cuts taken consecutively will be appreciably less than shown. These data show marked differences in yield and quality for various crudes. In the gasoline range, the yield of prime-cut naphtha varies from 6 to 33 per cent and its octane number from 45 to 72. The yield of potential Diesel fuel varies from 10 to 50 per cent, the sulphur content from 0.04 to 2.2 per cent, the pour point from minus 60°F. to plus 5°F., and the Diesel index from 30 to 72. Lubricating oil distillates vary from below 0°F. to 115°F. in pour point and from minus 60 to plus 95 in viscosity index on products dewaxed to a pour point of 0°F. The most commonly used yardstick of quality in crude is the gravity but it should be observed that these wide differences in quality of products are not necessarily indicated by changes in the gravity of the crude.

A refiner who has only a skimming plant or one not equipped with cracking and other modern processing units can use the crude-assay data directly in computing the relative values of the crudes available to him. However, such a refiner has to accept the quality of the products produced and be satisfied with them or if he insists on making a specified quality he must shop around to find a suitable crude.

A refiner with cracking and other forms of modern processing equipment is less limited in his choice of crudes since he can in most instances make up for natural deficiencies in quality by proper processing. The octane of the natural or prime cut naphtha can be increased by thermal or catalytic reforming (a form of cracking). Gas oil and heavy distillates (and if necessary kerosene) can be cracked to produce gasoline of good octane number. Inferior quality kerosenes can be converted into good quality kerosenes by solvent extraction. Poor quality distillates can be converted into superior lubricating oils by the use of dewaxing and solvent extraction processes. Numerous other examples could be cited. However, this improved quality is secured only at a cost, because not only the manufacturing expense is increased but the yield is reduced. For example, a yield of roughly 75 per cent is obtained in reforming a 45 octane number to 70, the other

[3] G. A. Beiswenger, "Factors Affecting the Refiner's Choice of Crude," *A.I.M.E. Petroleum Technology* (February, 1940).

25 per cent being converted into gas and fuel oil, products that have relatively low values. Thus, although a crude with a low value on the basis of its assay can be used for the production of a line of good-quality products, its value as a raw material for this processing may be as low as, and perhaps even lower than, its crude assay value.

A crude may be evaluated on an "ultimate-yield" basis, in which it is assumed that, by means of cracking, the crude is converted entirely into gasoline, fuel oil, and gas, or on a "middle-distillate" basis, where it is assumed that normal yields of kerosene and domestic furnace oil are obtained and the balance converted into gasoline, fuel oil, and gas. In making these evaluations, it is not necessary to subject the distillates obtained in the assay to laboratory cracking, solvent extraction, *et cetera*, but the yields and quality improvement to be obtained are computed on the basis of the data obtained in the crude assay.

These crude-assay data and the subsequent calculations based on them enable a refiner to determine how much he can afford to pay for a given crude delivered to him at his refinery and to set up differentials in value to him for various crudes. However, since the crude is normally purchased at the well, the well value is based on the value at the refinery less the cost of transportation (by pipe line and/or tanker) from the well to the refinery. It is perhaps obvious that the posted price is not necessarily exactly equal to the refinery value less the cost of transportation since supply and demand and other factors, some of them political and others equally artificial, may have some bearing on the posted price. Furthermore, the posted prices are seldom dependent upon a single refinery's evaluation and location, but are based on an average for the refining center serving as the principal market for the crude. In general, crudes produced near a refining center enjoy higher posted prices than crudes of similar quality from fields remote from the refining center. Thus an individual refinery located near a field far removed from a refining center can take advantage of the low posted price prevailing in the field.

Some crudes serve as a source of high-priced specialty products, such as aviation gasoline, solvents, and premium motor oils, but this is seldom taken into consideration in evaluating the crude. For example, some crudes serve as a source of solvents that command prices three or four times that of motor gasoline but this is ignored in making the evaluation. This is because usually only a single refinery uses the crude for the specialty in question and the other refiners can not pay a higher price merely because one refiner is producing a specialty product. Furthermore, the market for such specialties is usually uncertain and variable so that the refiner has no assurance of a con-

tinued favorable situation. It is usually conceded that if a refiner makes a profit out of a specialty business he is entitled to it as a reward for his aggressiveness.

In conclusion, it should be apparent that crudes are not quite similar, but instead show very real differences in composition and this in turn affects the quality of the products made therefrom. Even modern refining methods do not completely overcome these differences and do so only at a cost. Consequently, crude values at the refinery differ widely and their value in the field (because of variable distances between the field and the refining centers) even more so. Differences in posted prices are, therefore, not the result of whim or caprice but in most cases have a real foundation in fact.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1175-1179, 1 FIG.

GEOLOGICAL NOTES

SIGNIFICANCE OF INITIAL DAILY PRODUCTION OF WELLS IN BURBANK AND SOUTH BURBANK OIL FIELDS, OKLAHOMA[1]

N. WOOD BASS[2]
Tulsa, Oklahoma

When the initial daily yields of all oil wells in the Burbank and South Burbank fields of Osage and Kay counties, Oklahoma, are plotted on a map (Fig. 1) it is found that the wells with large initial daily yields lie in long, narrow belts. These belts parallel the curved eastern margins of both the reservoir sand bodies and the oil pools; and in the northern part of the Burbank field they curve westward so that they nearly parallel the northern margin of that field.

A belt about a mile wide, extending through Secs. 22, 23, and 24, T. 27 N., R. 5 E., and Secs. 19 and 29, T. 27 N., R. 6 E., contains the most prolific oil-bearing sand in the Burbank field. Within this belt there are 17 tracts of 160 acres each that by the end of 1940 had yielded a total of 35,223,701 barrels, a little more than one-sixth of the total amount produced from the entire Burbank field. Wells within these tracts have had both large initial and large total yields.

An earlier investigation[3] of the thickness of the reservoir sand bodies of the two fields showed that the reservoir sand bodies are large lenses ranging in thickness from a feather edge to more than 100 feet and that they contain narrow curved belts of thick sand. The trends of these belts of thick sand are similar to the trends of the belts of large-yielding oil wells.

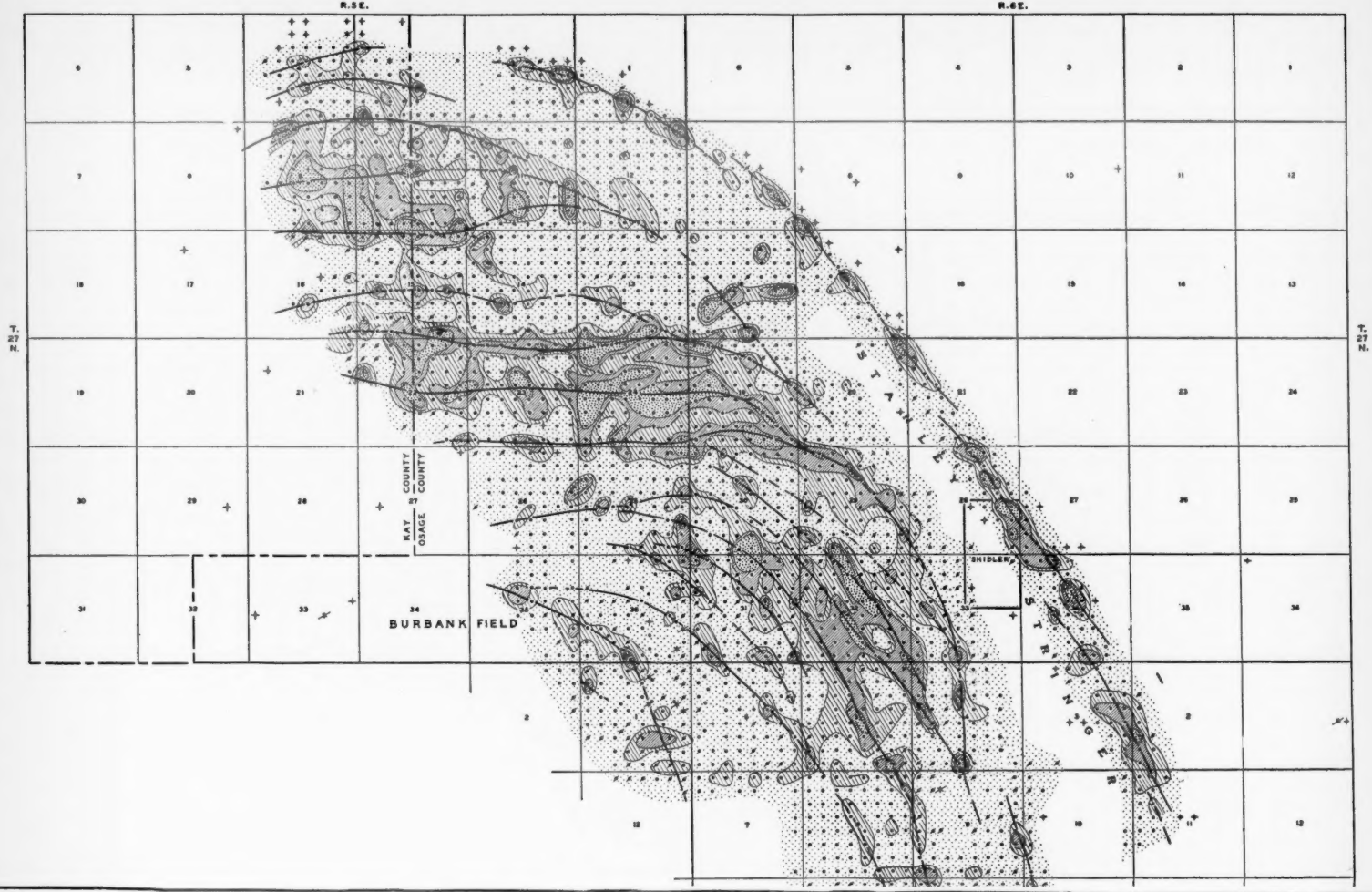
It was pointed out in the earlier report that (1) the ridges of thick sand in the Burbank and South Burbank fields appear to represent beach-growth ridges in offshore bars that were formed on the western shore of the Pennsylvanian sea; and (2) that the sand bodies grew progressively eastward and northward as a series of overlapping beaches beginning at the southwest margin of the Burbank field.

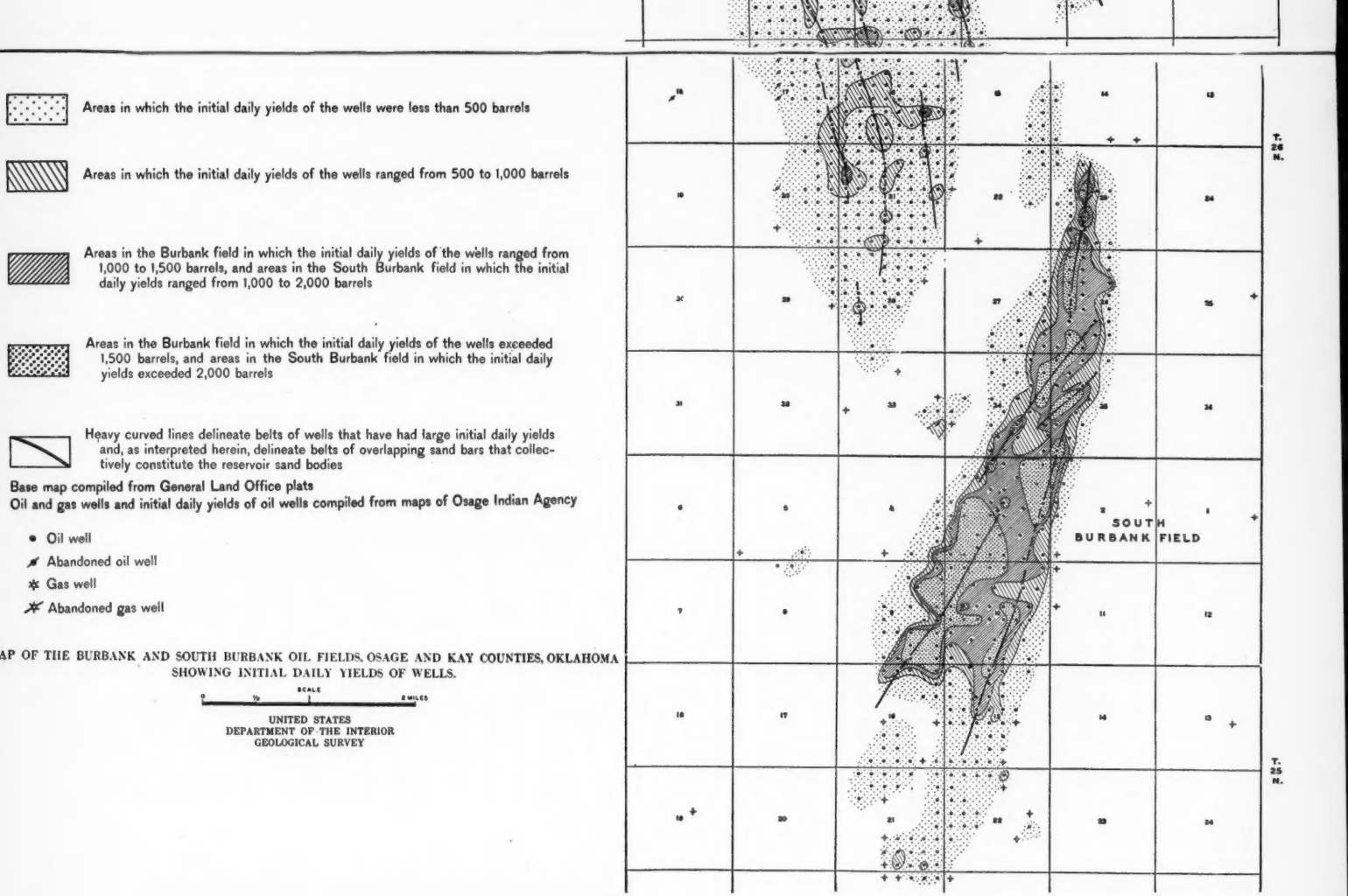
Narrow sand bars parallel with the shoreline are built by waves and longshore currents. The margins of a bar feather out into the

[1] Manuscript received, April 11, 1941. Published by permission of the director of the Geological Survey, United States Department of the Interior.

[2] Federal Building.

[3] N. W. Bass, Constance Leatherock, W. R. Dillard, and L. E. Kennedy, "Origin and Distribution of Bartlesville and Burbank Shoestring Oil Sands in Parts of Oklahoma and Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 1 (January, 1937), pp. 30–66.


R.5E.
R.6E.
T. 27 N.
T. 27 N.
KAY COUNTY
OSAGE COUNTY
SHIDLER
BURBANK FIELD
STATE LINE



MAP OF THE BURBANK AND SOUTH BURBANK OIL FIELDS, OSAGE AND KAY COUNTIES, OKLAHOMA SHOWING INITIAL DAILY YIELDS OF WELLS.

FIG. 1

fine-grained sediment of the adjacent deposits, but a longitudinal zone in the middle of a bar consists largely of well sorted clean sand. Such a zone would accordingly be the most highly permeable part of the sand bar. Oil wells with large initial yields in the Burbank and South Burbank fields obtain their oil from the more permeable parts of the reservoir sands; and the narrow zones containing such wells in these pools are believed to be the middle portions of many overlapping sand bars that collectively form the large sand bodies.

During the long time consumed in the deposition of the large sand body of the Burbank field doubtless the crests of many ridges were planed off by waves, wind, and rain and the swales between the ridges were filled. The surface relief on many of the bars that constitute the sand body was therefore destroyed, but the permeability and other features in the remaining portions of the bars were not affected.

The sand body of the Stanley stringer, as shown by its thickness and distribution, is a narrow bar-shaped body, extending southeastward continuously for many miles; but the alignment of the belts showing the initial daily yields of the wells indicates that this sand body really consists of a series of relatively short, closely associated sand bars that trend northwest across the main sand body and have an offset arrangement, like the offset arrangement of sand bars on most of our recent coasts.

The offset arrangement of the individual segments of the Stanley stringer sand body apparently has not been generally recognized, for the wells in Secs. 11 and 14, T. 26 N., R. 6 E., except those in the NW. $\frac{1}{4}$, NW. $\frac{1}{4}$ of Sec. 11, were drilled west of the southeastward-trending belt lying in the W. $\frac{1}{2}$ of Sec. 11, and possibly extending into Sec. 14.

Application to repressuring.—The determination of the relative permeability of the reservoir sand body throughout an oil field is important in planning for repressuring the sand with gas or water. Such data are most likely to be acquired by laboratory permeability tests made of cores of the sand taken specifically for that purpose. Where such cores are unavailable, however, it is believed that a map such as Figure 1 will supply much information about the permeability of the sand that can be used in planning the repressuring project. The narrow belts containing wells whose initial daily yields have been large are believed to represent belts in which the sand has high permeability, and the belts containing wells whose initial daily yields were small are believed to represent belts in which the sand has relatively low permeability. The intake (or pressure) wells should be distributed along the belts in such a manner as to allow for the changes

in permeability laterally from one belt to another rather than at equi-distant sites throughout the pool.

Inasmuch as the belts cross leased properties of different ownerships, any plan for locating intake wells along the belts would necessitate the coöperation of many owners. Some sort of a unit plan of operation for relatively large parts of the field, therefore, would be necessary to make such a plan practicable.

Recent results in water-flooding a shoestring sand body in the Cherokee shale near Chanute, Kansas, have shown that the flood water travels faster lengthwise the sand body than across it.[4] Inasmuch as the sand body at Chanute lies near the stratigraphic position of the Burbank sand and is believed to have been formed in a similar manner as the Burbank sand, the behavior of the water injected into the sand is noteworthy; it appears to bear out the contention that the most permeable parts of sands of this type lie in belts that trend lengthwise the sand bodies.

[4] W. R. Dillard, D. P. Oak, and N. W. Bass, "Chanute Oil Pool—a Water-Flooding Operation," *Stratigraphic Type Oil Fields* (Amer. Assoc. Petrol. Geol., in preparation, 1941).

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), P. 1180

DISCUSSION

WHERE SHOULD YOUNG GRADUATES IN PETROLEUM GEOLOGY ACQUIRE FIELD EXPERIENCE?[1]

RALPH B. ROSS[2]
Pittsburgh, Pennsylvania

The previous discussions of this question appear to assume that since some of our prominent petroleum geologists began their careers mapping surface geology that the new graduates should go through the same motions even though the demand for such work has decreased. However, there is another major source of field training for young petroleum geologists, one which includes a reservoir of men with practical field experience as pertinent to the practice of petroleum geology as "anticline hunting" ever was. These men are graduate geologists, petroleum geologists, civil engineers, and others, and are already in the oil company's employ; they are familiar with their company's policies and personnel, familiar with their lease maps, subsurface maps and their wildcat and producing areas. They are in the geophysical departments. I do not mean the physicists who pioneered and now direct most geophysical work; I mean their field force: college graduates who are doing to-day's structure mapping.

There is more to gravity mapping than "milligals" or "shape of the geoid." Surface density profiles have given many gravity operators a real knowledge of areal geology and gravity mapping has furnished them a knowledge of regional tectonics far beyond the extrapolation of a few wildcats into "trends."

In seismograph field work favorable geophone spreads and shot depths depend on detailed local knowledge of surface formations and that knowledge is gleaned from logs of as much as 20,000 or 30,000 feet of shot-holes drilled each month. Directing this drilling involves detailed water-table surveys, careful correlation of the shot-hole logs, and dealing with caving holes, cavernous holes, blind holes, and casing problems.

Seismic interpretation furnishes subsurface data on several horizons that reveal convergence, migration of structural axes with depth, and many subsurface details in large undrilled areas and at depths that are, as yet, beyond the reach of the drill.

These geophysical crews work over all of the oil-producing and prospect areas in the United States, following every new play they do not precede. In each new area the geological department of the parent or contracting company usually furnishes all the geological information available and the geophysicist goes on from there. His job is structure mapping and his interpretation problems generally contain less inference than does subsurface mapping from surface work or from widely scattered wildcat well data.

These geophysical crews are an ideal training and proving ground for young graduates in petroleum geology. Let them first do the surveying necessary for geophysical work and if they can qualify let them next do the observing, then the computing and interpretation. During that period, for at least several years, have them cover as much area as possible. They will have real field experience and also will be valuable appraisers of the geophysical data that have become a large part of a petroleum geologist's work.

[1] Manuscript received, April 10, 1941.

[2] Gulf Research and Development Company.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1181-1185

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library and available, for loan, to members and associates.

STRENGTH AND STRUCTURE OF THE EARTH, BY REGINALD ALDWORTH DALY

REVIEW BY ROLAND F. BEERS[1]
Cambridge, Massachusetts

Strength and Structure of the Earth, by Reginald Aldworth Daly. 434 pp., 85 figs., 69 tables. Prentice-Hall Geology Series, New York (1940). $3.50.

Professor Daly has often remarked that one of his principal interests in life is to stimulate creative thinking by provocative discussion. His numerous publications ably testify to this fact and this latest volume is no exception.

From the viewpoint of the geologist Professor Daly has assembled in one place the data and meaning of thousands of pages of authentic documents pertaining to his topic. So great is the mass of evidence and so inaccessible are many of the papers that his audience must be everlastingly grateful to him on this account alone. The purpose of the text is to estimate, as closely as the data warrant, the internal structure of the earth and the strength of the concentric shells forming the principal elements of this structure. Dr. Daly exhibits a respect for the procedures of modern physicists, and emulates their custom in setting up a number of earth models which are to be judged in the light of the data here assembled. In this field, the number of models almost corresponds with the number of writers on the subject, but each one is here presented impartially, so that the reader may form his own opinion in the light of this great array of facts.

The facts by which the various earth models are to be tested are largely geophysical. Here is the vision of a serious worker in the field of geology who sees in geophysics the opportunity to extend his already experienced faculties into realms hitherto beyond his reach. By the use of the pendulum, torsion balance, gravimeter, and seismograph the geologist is enabled to see below the surficial layers which have long been his realm of exploration.

In this field the monumental work of J. F. Hayford, aided by Bowie, laid the basis of determining the extent to which isostasy is achieved in the earth. The early work with the deflection of the vertical compares favorably with the conclusions afforded by the later gravity measurements. There is a tendency for some to think that Hayford held closely to the Pratt theory of isostasy, embodying purely local compensation. This is not the case as stated by Hayford himself. This theory was adopted largely as a convenience so that a start might be made on the enormous task of computation. Upon the completion of his work, Hayford saw as clearly as others that a more acceptable theory would involve regional compensation and a variable isopiestic level. In the field of speculation on the theory of isostasy the works of Pratt and Airy, of Dutton, Putnam, Lambert, and Barrell in America, of Kossmat, Salonen, Niethammer, and Mace in Europe, and of Bullard, Oldham, Glennie, and Hunter in Africa and Asia, are also worthy of mention. The enormous efforts of Vening Meinesz, both from the Netherlands and from this country, are well known to workers in the field of gravity measurements. One notes a

[1] The Geotechnical Corporation Research Laboratory, 580 Massachusetts Avenue.
Manuscript received, February 14, 1941.

special appreciation by Professor Daly of the great task which W. Heiskanen is even now pursuing in Finland, in the effort to reduce the diverse forms of evidence to a common basis and an acceptable figure of the earth.

The reader approaching this subject for the first time may lack a sense of proportion which will help him to realize the meaning of the various chapters. The extent of the data is so great that eleven of the twelve chapters are devoted to a report of these facts and the manner in which they were collected. To grasp the full meaning of the text, it will be helpful for the reader to concentrate on this point. Otherwise, he may be inclined to lose interest in the pervading thesis and to become absorbed in the technique of data collection and interpretation. This characteristic of geophysical data is often a barrier to penetrating thinking but may be offset if the danger is anticipated.

The author is particular to give every contribution of data fair and adequate consideration and thereby adds much material that may not seem pertinent to the principal topic. However, this subject is extremely controversial. Many eminent workers differ widely in their appraisal and interpretation of these complicated figures. Professor Daly does not presume to settle these differences arbitrarily here, but prefers rather to set down facts so the reader may judge for himself.

In the final chapter a distribution of strength in the earth model is suggested. The models of Jeffreys, Gutenberg, Washington, Darwin, Barrell, Heiskanen, and others are all displayed so that the reader may form his own views.

The modern conception of strength and plastic deformation is supported by references to the works of Bridgeman, Griggs, and Birch. A unique test of the earth models is afforded by the effects of Pleistocene ice loads on various earth sectors. In this field the work of Sauramo, Pesonen, Gutenberg, Gilbert, and Nansen is important. Not included in this book is Professor Daly's "Theory of Glacial Control" of living coral reefs. This topic, adequately covered in his "The Changing World of the Ice Age," is not pertinent to the subject of earth strength, although many another writer has included coral-reef data among this evidence.

A tribute is paid inferentially to Dr. Vening Meinesz, of the Netherlands, and more recently of the United States Coast and Geodetic Survey, who developed the under-water gravimeter and made the first world-circling gravity survey. Outstanding in all of the chapters is the generous tribute paid to those who have added substantial evidence to this field of knowledge.

Some of the conclusions suggested by the author are the following.

1. Isostasy is generally achieved on a regional basis all over the earth.
2. Local departure from isostasy gives a measure of the strength of the earth's crust, that is, present load on the crust in local areas.
3. The crust rests on a comparatively thin layer, which, if not fluid in the customary sense, at least has little strength.
4. The strength of the earth's crust may equal twice that of granite under continents, and be still greater beneath deep oceans.
5. The load in excess of that which the crust can carry, is borne by the interior mesospheric "strong" shell. The figure of the mesosphere is probably a tri-axial ellipsoid to which the lithosphere may be roughly conformable.
6. The figure of the earth best fitted to accepted gravity and geodetic data is the Heiskanen 1938 tri-axial ellipsoid.

A number of minor errors escaped the notice of the proof reader and these, as well as those connected with the explanation of certain equations, will undoubtedly be corrected in a second printing. Subjects of this type are noted for these minor discrepancies and it is difficult to see how they may be avoided except through the mechanism of distribution and criticism.

RECENT PUBLICATIONS

ARGENTINA

*"Observaciones geológicas en el Cerro Valdivia" (Geological Observations in the Cerro Valdivia), by Blas v. Alascio. *Y.P.F. Bol. Inf. Petrol.*, Vol. 18, No. 198 (Buenos Aires, February, 1941), pp. 12–37; 8 pls., 24 photomicrographs.

CALIFORNIA

*"Report on the Williams Area of Midway Sunset Oil Field," by W. T. Woodward. *California Oil World*, Vol. 34, No. 7 (Los Angeles, April, 1941), pp. 3–9; photograph, structure section, columnar section, and structure-contour map.

CENTRAL EUROPE

*"Die Erdölfelder Westgaliziens" (The Oil Fields of Western Galicia), by A. Mayer-Gürr. *Oel und Kohle*, Vol. 36, No. 27 (Berlin, July 15, 1940), pp. 251–54; 5 figs.

"Stand und Aussichten der angewandten Mikropaläontologie in den Erdölfeldern Westgaliziens" (Status and Prospects of Applied Micropaleontology in the Oil Fields of Western Galicia), by Heinrich Hiltermann. *Ibid.*, Vol. 36, No. 31 (August 15, 1940), pp. 289–91; pl. of microfossils.

GENERAL

"Geology and Biology of North Atlantic Deep-Sea Cores between Newfoundland and Ireland; Summary of the Report." Foreword by C. S. Piggot; General Introduction by W. H. Bradley; Part 1, Lithology and Geologic Interpretations, by M. N. Bramlette and W. H. Bradley; Part 2, Foraminifera, by J. A. Cushman and L. G. Henbest. *U.S. Geol. Survey Prof. Paper 196A* (February, 1941). xv and 56 pp., 10 pls., 21 figs. Sold by Supt. of Documents, Govt. Printing Office, Washington, D. C. Price, $0.30.

**Petroleum Facts and Figures.* 7th ed. American Petroleum Institute, 50 West 50th Street, New York City (1941). 192 pp. Price, $1.00.

*"Modern Developments in Geological Exploration for Petroleum," by Arthur Wade. *Modern Engineer* (Melbourne, Australia, January 20, 1941). 8-page reprint.

GERMANY

*"Zur Stratigraphie der Grenzschichten Jura-Kreide Nordwestdeutschlands" (Stratigraphy of the Border Beds of the Jura-Cretaceous of Northwestern Germany), by C. A. Wicher. *Oel und Kohle*, Vol. 36, No. 29 (Berlin, July 30, 1940), pp. 263–69; 3 figs., 3 pls. of microfossils.

KANSAS

*"Stratigraphy and Paleontology of a New Middle and Upper Pliocene Formation of South-Central Kansas," by John C. Frye and Claude W. Hibbard. *Jour. Geol.*, Vol. 49, No. 3 (Chicago, April-May, 1941), pp. 261–78; 6 figs.

LOUISIANA

*"Bright Future in Prospect for Louisiana Development," by J. Huner, Jr. *Oil and Gas Jour.*, Vol. 39, No. 49 (Tulsa, April 17, 1941), pp. 69–71; 100–03; geologic cross section.

*"The Sand and Gravel Deposits of Louisiana," by T. P. Woodward and Albert J. Gueno, Jr. *Louisiana Geol. Survey Bull. 19* (New Orleans, April 1, 1941), pp. 1–365; 3 pls., 36 figs., 4 tables. Also bound in this bulletin: "Subsurface Pleistocene of Louisiana," by John W. Frink, pp. 369–419; 2 pls., 7 figs.

NEBRASKA

*"Geology of Western Nebraska Demands Careful Prospecting," by W. V. Howard. *Oil and Gas Jour.*, Vol. 39, No. 51 (Tulsa, May 1, 1941), pp. 11 and 24, map and section.

NEW MEXICO

*"Quaternary Geology of the San Acacia Area, New Mexico," by Charles S. Denny. *Jour. Geol.*, Vol. 49, No. 3 (Chicago, April-May, 1941), pp. 225–60; 16 figs.

NEW YORK

"Geologic Structure and Occurrence of Gas in Part of Southwestern New York, Part 2, Subsurface Structure in Part of Southwestern New York and Mode of Occurrence of Gas in the Medina Group," by G. B. Richardson. *U.S. Geol. Survey Bull. 899 B* (February, 1941), pp. i–iii, 69–93, Pls. 5–8. Sold by Supt. Documents, Govt. Printing Office, Washington, D. C. Price, $0.30.

NOVA SCOTIA

*"The Pictou Coalfield, Nova Scotia," by W. A. Bell. *Canada Geol. Survey Mem. 225* (Ottawa, Canada, 1940). 162 pp., 10 pls., 2 maps folded in pocket. Price, $0.50.

ONTARIO

*"Palaeozoic Geology of the Toronto-Hamilton Area, Ontario," by J. F. Caley. *Canada Geol. Survey Mem. 224* (Ottawa, Canada, 1940). 284 pp., 2 maps folded in pocket. Price, $0.75.

PENNSYLVANIA

*"Oil Geology of the Titusville Quadrangle, Pennsylvania," by Parke A. Dickey. *Pennsylvania Geol. Survey Bull. M22*, 4th Ser.(Harrisburg, 1941). 87 pp., 13 figs. 6 tables, 6 sections, 6 pls.

RUSSIA

*"Das neue Erdölgebiet zwischen der Wolga und dem Ural 'Das zweite Baku'" (The New Oil Region between the Volga and the Urals, "the Second Baku"), by N. Polutoff. *Oel und Kohle*, Vol. 36, No. 13 (Berlin, April, 1940), pp. 113–17; 5 figs.; Vol. 36, No. 15, pp. 137–40; 3 figs.

TEXAS

*"Producing Horizons of Coastal Sector of South Texas," by J. C. Poole. *Oil and Gas Jour.*, Vol. 39, No. 49 (Tulsa, April 17, 1941), pp. 66–68; map, section, chart.

*"The Eocene Wilcox," by S. Russel Casey. *Ibid.*, pp. 74–76; 106–10; 3 figs.

*"Quaternary Sands on the Southern High Plains of Western Texas," by Roy M. Huffington and Claude C. Albritton, Jr. *Amer. Jour. Sci.*, Vol. 239, No. 5 (New Haven, Connecticut, May, 1941), pp. 325–38; 1 fig., 1 pl., 2 tables.

URUGUAY

*"Estado Actual de Nuestros Conocimientos Sobre la Geologia de la Republica Oriental del Uruguay" (Geology of Eastern Uruguay), by Roger Lambert. *Inst. Geol. Uruguay Bol. 29* (Montevideo, November, 1940). 89 pp., 28 pls., 1 folded map.

ASSOCIATION DIVISION OF PALEONTOLOGY AND MINERALOGY

**Journal of Sedimentary Petrology* (Tulsa, Oklahoma), Vol. 11, No. 1 (April, 1941).

"A Hydrometer-Pipette Method for Mechanical Analysis," by N. N. Hellman and V. E. McKelvey

"The Probable Error of Sampling Beach Sand for Heavy Mineral Analysis," by W. C. Krumbein and W. C. Rasmussen

"Near Shore Coral Lagoon Sediments from Raiatea, Society Islands," by J. R. Stark and E. C. Dapples

"A Diaphragm Method for Grain Size Analysis," by Harold L. Alling

"The Stability of Minerals in Sandstone," by M. N. Bramlette

"The Classification of Wave-formed Ripple Marks," by O. F. Evans

"Dominant Factors in the Formation of Firm and Soft Sand Beaches—A Discussion," by Joseph M. Trefethen

**Journal of Paleontology* (Tulsa, Oklahoma), Vol. 15, No. 3 (May, 1941).

"Cambrian Brachiopoda from Montana," by W. Charles Bell

"Jurassic Fossils from Arkansas, Louisiana, and Eastern Texas," by Ralph W. Imlay

"A New Coral from the Pliocene of California," by J. Wyatt Durham

"New Corals: one Recent, Alaska; three Eocene, Alabama and Louisiana," by Thomas Wayland Vaughan

"Lower Cretaceous Rocky Mountain Nonmarine Microfossils," by Raymond E. Peck

"*Oligopygus nancei*, a New Echinoid from Venezuela," by C. Wythe Cooke

"Two New Giant Scalas from Cuba," by Paul Bartsch

"*Prograngerella*, a New Ancestral Land Snail from the Upper Cretaceous of Alberta," by Loris S. Russell

"Permian Pelecypods in the Lower Quartermaster Formation, Texas," by Robert Roth, Norman D. Newell and Benjamin H. Burma

"*Leptolepis nevadensis*, a New Cretaceous Fish," by Lore David

"A Second Specimen of *Cephalaspis patteni* from the Upper Devonian of Scaumenac Bay," by George M. Robertson

"A Pathologic Pygidium from the Upper Cambrian of Missouri," by Christina Lochman

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1186-1191, 2 FIGS.

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Hugh Hamilton Beach, Ottawa, Ont., Canada
George S. Hume, Theo. A. Link, E. H. Hunt

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L. Kehrer, H. I. Tschopp, Roy W. Merritt

Karl Theodor Goldschmid, Quito, Ecuador, S. A.
L. Kehrer, H. I. Tschopp, Roy W. Merritt

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WEST TEXAS GEOLOGICAL SOCIETY STUDENT MERIT AWARD

The West Texas Geological Society Student Merit Award, consisting of a 2-year paid-up associate membership in the Association, has been made this year to Harry Max Britt, Jr., of the Texas College of Mines, El Paso, and to Robert Estes Rankin, of the Texas Technological College, Lubbock. In addition to the award of the West Texas Geological Society, the Association presents to each honoree a copy of the latest cloth-bound volume of the A.A.P.G. *Bulletin.*

HARRY MAX BRITT, JR.

ROBERT ESTES RANKIN

HARRY MAX BRITT, JR., B.S. in mining engineering, June, 1941, College of Mines and Metallurgy, El Paso, Texas (1938–1941). Born, February 6, 1918, Amarillo, Texas.

ROBERT ESTES RANKIN, B.S. in petroleum engineering, June, 1941, Texas Technological College, Lubbock, Texas (1937–1941). Born, May 25, 1917, Midland, Texas.

NATIONAL SERVICE COMMITTEE

A special committee has been appointed for the following purposes.

First—To recommend to the executive committee those plans which will enable the Association to render the most effective service to the nation during the present emergency.

Second—To coöperate with the National Roster of Scientific and Specialized Personnel, by recommending the men best fitted to fill such emergency positions as may become necessary.

The committee is composed of

FRITZ L. AURIN, *chairman*

BEN C. BELT — FRANK A. MORGAN
EUGENE HOLMAN — W. E. WRATHER

It is possible that the work of this committee may become rather arduous, and all members of the Association are requested to give these men whatever help may be solicited.

EXECUTIVE COMMITTEE

By ED. W. OWEN

PACIFIC SECTION ANNUAL MEETING
LOS ANGELES, OCTOBER 16–17

The annual fall meeting of the Pacific Section of the Association will be held this year on October 16 and 17 instead of November 6 and 7. The change in dates is made to avoid conflict with the American Petroleum Institute meeting in San Francisco, November 3–7.

The Pacific Section will meet at the Ambassador Hotel, Los Angeles, California, October 16 and 17. MAX L. KRUEGER, Union Oil Company, is chairman of arrangements and MASON L. HILL, Richfield Oil Corporation, is chairman of the technical program. The officers of the Section are E. WAYNE GALLIHER, Barnsdall Oil Company, president, and E. J. BARTOSH, Bankline Oil Company, secretary-treasurer.

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1942	1944
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BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), PP. 1192-1199

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

C. T. JONES, of the Stanolind Oil and Gas Company's Wichita, Kansas, district office, has been ordered to a year's active duty with the rank of Captain at the Engineer School at Fort Belvoir, Virginia, effective May 2, 1941. W. C. IMBT will assume direction of Stanolind's Wichita office as geologist in charge.

Because of the transfer of M. D. HUBLEY to Kansas, the office of secretary-treasurer for the Shawnee Geological Society has been filled by Miss MARTYNA GARRISON.

E. W. JOHNSON, of the Ohio Oil Company, has been transferred from St. Joseph, Missouri, to Falls City, Nebraska.

ROBERT M. KLEINPELL has returned from the Philippine Islands to 273 South Hudson, Pasadena, California.

J. GORDON COLE is in the exploration department of the Union Pacific Railway Company, 422 West Sixth Street, Los Angeles, California.

WILHO J. KIVI, recently with the Wyoming Geological Survey, Laramie, is with the 42d Engineers, Co. H & S, Camp Shelby, Mississippi.

W. D. MCBEE, JR., recently with the Shell Oil Company, Inc., at Wichita, Kansas, is in Battery B, 2d Field Artillery Observation Battalion at Fort Sill, Oklahoma.

G. D. JOHNSON, recently exploration geologist with the Standard Oil Company, Venezuela, has accepted a position in the geological department of the Shell Oil Company, Inc., Tulsa, Oklahoma.

F. M. AYERS has returned to the Dutch East Indies. His address is N.K.P.M. Soengei Gerong, Palembang, Sumatra.

H. E. WARD, recently with the Mid-Continent Petroleum Corporation, is now employed by the Forest Development Corporation, San Antonio, Texas.

ROY W. MERRITT has returned from Guatemala City, Guatemala, and may be addressed at 8th Floor, 50 West 50th Street, New York City.

MILAN D. MARAVICH, who received the degree of Master of Arts from the University of Wyoming, Laramie, in 1940, is employed by the Stanolind Oil and Gas Company, Tulsa, Oklahoma.

CLIVE MENDELSOHN is leaving Lisbon to carry out a geological survey in Africa for the Portuguese Government.

GRADY KIRBY, consulting geologist, is located at Mt. Vernon, Illinois, Postoffice Box 528. He retains an office also at 1915 Alamo Bank Building, in care of Adams and Lyles, San Antonio, Texas.

CHARLES GILL MORGAN is president of the Morgan Engineering Corporation of Dallas and New York. His residence address is Apartment 196, Arlington Village, Arlington, Virginia.

CHESTER W. WASHBURNE, consulting geologist, New York City, talked on "Oil Migration in the Light of the Theory of Least Energy" on Monday, April 14, and R. E. DICKERSON, chief geologist of the Atlantic Refining Company, Philadelphia, Pennsylvania, lectured on "The Use of Aerial Photographs in Geological Mapping," to the students in geology at Rutgers University, New Brunswick, New Jersey, on Saturday, April 19.

DON O. CHAPELL, of the Transwestern Oil Company, San Antonio, Texas, talked on the "Glen Field of Webb and Zapata Counties, Texas," at the South Texas Geological Society luncheon, San Antonio, April 14.

RICHARD H. PENCE, member of the engineering staff of the California Oil Administrator's office, has been called to active duty with the United States Navy. Pence holds the rank of Lieutenant in the U. S. Naval Reserve and reported for assignment on May 5.

The geological programs in celebration of the fiftieth anniversary of the University of Chicago will be held under the joint sponsorship of the Geological Society of America, Section E of the American Association for the Advancement of Science, and the University of Chicago. Presentation of papers will be by invitation but will be followed by open discussion. The sessions will be held on September 25 and 26. The theme underlying the program will be "Frontiers of Knowledge in the Geologic Sciences." The principal speaker at the sessions will be Professor REGINALD A. DALY of Harvard University whose topic will be "Continental Terraces and Submarine Valleys." This paper will probably be given at an evening session. The sessions will include four half-day programs as follows: "Frontiers of Knowledge in the Field of Glacial Geology," under the leadership of Professor RICHARD FOSTER FLINT of Yale University; "Frontier Studies of the Physical Constitution of Coal and Their Practical Significance," under the leadership of GILBERT H. CADY, senior geologist of the Illinois Geological Survey; "Frontier Researches on the Structure, Properties and Occurrence of Clay Materials, and Their Practical Application," under the leadership of RALPH E. GRIM, petrographer of the Illinois Geological Survey; "Geological Frontiers in the Search for Oil," under the leadership of A. I. LEVORSEN, chairman of the research committee of The American Association of Petroleum Geologists. Members of The American Association of Petroleum Geologists are cordially invited to be present at these sessions. Further details in regard to the program will be announced later. Inquiries may be addressed to Professor EDSON S. BASTIN, chairman, department of geology, Rosenwald Hall, University of Chicago.

WAYNE C. RAUCH is in the employ of the Lion Oil Refining Company, geological department, El Dorado, Arkansas.

EUGENE C. REED, assistant State geologist of Nebraska, talked on "Geologic Phases of Recent Oil Development in Southeast Nebraska," before the Tulsa Geological Society, May 12.

DAVID DONOHUE, consulting geologist of Fort Worth, Texas, is the author of "The Location of Quivera," printed in the *Panhandle Plains Historical Review*.

JOHN W. THOMAS, formerly with the California Arabian Standard Oil Company, Bahrein Island, Persian Gulf, may be addressed at 5657 Twelfth Avenue N.E., Seattle, Washington.

CHARLES L. LAKE is with the Tide Water Associated Oil Company at Houston, Texas.

L. W. FOLSOM has left the Equitable Gas Company, Pittsburgh, Pennsylvania. He is now assistant geologist with the West Virginia Geological Survey at Morgantown.

W. M. PLASTER is geologist with G. H. Vaughn and the Big West Drilling Company of Dallas, Texas. His headquarters office is 303 Atlas Building, Shreveport, Louisiana.

E. DEGOLYER, consultant of Dallas, Texas, addressed the Division of Geology and Geography of the National Research Council at Washington, D.C., May 3, on the subject, "Oil and War."

Geochemical Well Logging is the title of a new 24-page illustrated booklet published by Geophysical Service, Inc., of Dallas, Texas, of which EUGENE MCDERMOTT is president.

LOUIS CLAUDE ROARK, son of LOUIS ROARK, recently with the British American Oil Producing Company, Tulsa, Oklahoma, is serving in the 160th Field Artillery, 45th Division, at Camp Barkeley, Abilene, Texas.

R. L. MARSTON is assistant general production superintendent of the Sun Oil Company at Dallas, Texas.

HERMAN F. DAVIES, recently manager of the producing department of the California Company at Denver, Colorado, is now vice-president in charge of operations and is located at New Orleans, Louisiana.

R. R. COPELAND, of the California Company, has been transferred from Houston to New Orleans.

The new officers of the South Texas Geological Society, of San Antonio and Corpus Christi, are: president, GENTRY KIDD, Stanolind Oil and Gas Company, San Antonio; vice-president, G. B. GIERHART, Humble Oil and Refining Company, Corpus Christi; secretary-treasurer, W. W. HAMMOND, Magnolia Petroleum Company, 1704 Alamo National Building, San Antonio.

LAWRENCE A. GOEBEL has left the Carter Oil Company at Monroe, Louisiana, to work for the Northwest Company, Weyburn, Saskatchewan.

BRAME WOMACK is employed by the Southern Production Company, 803 Deposit Guaranty Bank Building, Jackson, Mississippi.

CARROLL E. DOBBIN, of the United States Geological Survey, Denver, Colorado, vice-president of the Association in 1937, has had conferred upon him by Colby College, Waterville, Maine, June 16, the honorary degree of Doctor of Science.

SCHUYLER B. HENRY, formerly with the South Mediterranean Oilfields, Ltd., at Cairo, Egypt, is with the Richmond Petroleum Company of Colombia, Bogota.

R. B. ("IKE") DOWNING, Mid-Continent consulting geologist, recently joined Lane-Wells Company as sales engineer-geologist. He will make his headquarters in the Union National Bank Building, Wichita, Kansas.

Preliminary announcement is made of the sessions of Section E (Geology and Geography) of the American Association for the Advancement of Science, at Dallas, Texas, during the week of December 29, 1941–January 2, 1942. Professor C. L. BAKER, Texas A. and M. College, College Station, Texas, is chairman of the program committee for papers on the structure and stratigraphy of the Southwest. A. N. SAYRE, U. S. Geological Survey, Washington, D.C., is in charge of a meeting on the Relation of the Geology to Ground-Water Problems in the Southwest. Professor EDWIN J. FOSCUE, Southern Methodist University, Dallas, Texas, has in preparation a program on the Regional Geography of the Southwest. Additional programs are under consideration and will be announced later. Members of the A.A.P.G. are urged to coöperate and to contribute their suggestions to the chairmen of the various program committees.—A. C. SWINNERTON, *secretary*, Section E, Antioch College, Yellow Springs, Ohio.

Much interest has been shown by Association members, and also by teachers and others who are not members, in the work of the committee on college curricula in petroleum geology. The committee has not yet completed its investigation and consequently has not arrived at final conclusions, but its preliminary report may be of some use to those who may wish to study its suggestions. This report will be found beginning on page 969 of the May number of the *Bulletin* for 1941. The committee has been trying to get a cross section of the opinions of geologists, teachers, and executives on what these people think might be done to improve present methods of preparing a student for professional work in petroleum geology. We shall therefore be grateful to any who care to submit their ideas.—F. H. LAHEE, *chairman*.

The West Texas Geological Society's annual spring field trip was held May 10–11 between Fort Worth and Midland with a total registration of 150. Some copies of the road log are still available. There is a 21-page supplement by V. C. PERINI which discusses problems of the El Reno and Whitehorse group. These logs will be especially valuable to anyone planning a trip on the Broadway of America highway between Midland and Fort Worth. They may be obtained from WALTER G. MOXEY, Stanolind Oil and Gas Company, Midland, The price is $2.00 per copy.

The Minister of the Interior of the Australian Commonwealth, Senator HENRY S. FOLL, has announced that an American oil production engineer would be engaged to make a thorough examination of the Victorian Lakes Entrance area for oil. The Government has asked the Australian Minister at Washington, RICHARD GARDINER CASEY, to engage an engineer who was expert in low-pressure, and low-yielding fields.

The itinerary of Association president, EDGAR W. OWEN, for the months of May and June included the meetings of the following societies.

West Texas Geological Society
South Louisiana Geological Society
Mississippi Geological Society
Appalachian Geological Society
Illinois Geological Society
Indiana-Kentucky Geological Society
Michigan Geological Society

JOHN D. TODD, of the firm of Roper and Todd of Houston, has joined the lengthening list of geologists to answer the call to colors. He is now Lieutenant Todd at the Advanced Flying School at Genoa, Texas.

The Council of the Geological Society of America has prepared a list of nominations for councilors and officers to become the regular candidates for election at the 1941 annual meeting, as follows: president, DOUGLAS JOHNSON, New York City; past-president, CHARLES P. BERKEY, New York City; First vice-president, E. L. BRUCE, Kingston, Ontario, Canada; Second vice-president, CHESTER R. LONGWELL, New Haven, Connecticut; Third vice-president, LLOYD W. STEPHENSON, Washington, D.C.; Fourth vice-president, FREDERIC E. WRIGHT, Washington, D.C.; secretary, H. R. ALDRICH, New York City; treasurer, EDWARD B. MATHEWS, Baltimore, Maryland; other councilors, 1942–1944, JOSEPH STANLEY-BROWN, Kew Gardens, L. I., New York, A. I. LEVORSEN, Tulsa, Oklahoma, ROLLIN T. CHAMBERLIN, Chicago, Illinois.

LEWIS B. KELLUM, of the University of Michigan, will return to northern Mexico to complete the mapping of Sierra de Tlahualilo and Sierra del Rosario in further study of the Coahuila Peninsula and the position of the continental margin in Mesozoic time. This is a project of the Geological Society of America and the University of Michigan.

J. STEWART WILLIAMS, of the Utah State Agricultural College, will spend 3 months correlating the Carboniferous rocks of the Wasatch with those of the Uinta Mountains and those of southeastern Idaho. The results will permit further correlations in Wyoming, Idaho, and Nevada and contribute to the paleogeography of the Rocky Mountain region. This is a project of the Geological Society of America.

The 1941 annual meeting of the Geological Society of America to be held in Boston, December 29–31, is being arranged by a local committee under general chairman M. P. BILLINGS. The Statler Hotel has been selected as the headquarters hotel, and all scientific sessions will be held there. The associated societies meeting with the Geological Society include the Paleontological Society, the Mineralogical Society of America, the Society of Economic Geologists, and the Society of Vertebrate Paleontology.

HAROLD N. HICKEY, of The California Company, has moved from Denver, Colorado, to New Orleans, Louisiana.

SPENCE T. TAYLOR resigned on March 1 from his position as petroleum engineer with the Tide Water Associated Oil Company at Santa Fe Springs, California, to accept a position as petroleum engineer with the Long Beach Oil Development Company, Long Beach, California.

R. T. CHAPMAN is a geological scout for the Stanolind Oil and Gas Company at Shreveport, Louisiana.

WILLIAM G. BLACKWELL is a petroleum engineer with the Louisiana State Department of Minerals at New Orleans, Louisiana.

CHARLES M. REED has been working for the General Geophysical Company at Bay City, Texas.

RICHARD S. HICKLIN is subsurface geologist for the Carter Oil Company in the Kentucky-Indiana district. He is stationed at Evansville, Indiana.

JOHN M. HILLS has resigned his position as geologist for the Amerada Petroleum Corporation, effective May 15, to take up independent consulting work. His address is Box 418, Midland, Texas.

New officers of the Panhandle Geological Society, Amarillo, Texas, are: president, E. H. POWERS, Gulf Oil Corporation; vice-president, EARLE N. ARMSTRONG, Shamrock Oil and Gas Corporation; secretary-treasurer, H. H. HINSON (re-elected), United States Bureau of Mines.

MILTON W. CORBIN, geologist with the Arkansas State Geological Survey, at Little Rock, Arkansas, for the past year, has accepted the position of geologist with the Skelly Oil Company at Shreveport, Louisiana.

J. L. BORDEN, of The Pure Oil Company, gave his presidential address at the annual meeting of the Tulsa Geological Society at Kendall Hall, Tulsa University, May 26: "Review of the Pennsylvanian of Oklahoma."

S. L. ROSE has returned from India, where he was with the Indian Oil Concessions, Ltd. He may be addressed in care of the Standard Oil Company of Texas, Petroleum Building, Houston, Texas.

C. W. TOMLINSON, Ardmore, Oklahoma, consulting geologist, gave a paper, "Recent Developments and Current Geological Problems in Southern Oklahoma and North Texas," before the Shawnee Geological Society at the May meeting.

O. F. SUNDT, former consulting geologist and geophysicist, 1401 Esperson Building, Houston, Texas, is now chief geologist for Texas Gulf Producing Company, Box 2199, Houston, Texas.

W. J. CLASSEN, consulting geologist, has changed his address from the Mills Building, San Francisco, to R.F.D. Box 330-D, Redwood City, California. He also has a mailing address in care of the Bohemian Club, Post and Taylor Streets, San Francisco.

PHIL K. COCHRAN, with headquarters at Shreveport, Louisiana, is division geologist in charge of exploration and land for the newly formed southern division of the Carter Oil Company which includes Louisiana, Arkansas, Mississippi, and Alabama.

FRANK S. HUDSON, former chief geologist in California for the Shell Oil Company, Inc., has joined the Yuba Consolidated Gold Fields as efficiency engineer. His address is in care of that company, 351 California Street, San Francisco.

D. T. SECOR, assistant geologist with the United Natural Gas Company, Oil City, Pennsylvania, since 1935, has succeeded D. E. CONAWAY as chief geologist. Conaway has become geologist for the Pennsylvania Gas Company at Warren, Pennsylvania.

GEORGE S. HUME, of the Geological Survey of Canada, at Ottawa, Ontario, has been transferred to the office of the federal oil controller to promote exploration in western Canada.

FRANK BUTTRAM, president of the Independent Petroleum Association of America, has been granted the honorary degree of doctor of laws by Phillips University, Enid, Oklahoma.

JOHN F. MASON, of the department of geology of Princeton University, is to be an instructor in the department of earth sciences, teaching structural and petroleum geology, at the University of Pennsylvania. He received the degree of doctor of philosophy at Princeton in June.

A. W. WEEKS, who has been teaching at the University of Texas, at Austin, the past year, received the degree of doctor of philosophy in geology and petroleum engineering in June.

JOSEPH E. POGUE, vice-president of the Chase National Bank, New York City, addressed the annual meeting of the National Oil Scouts and Landmen's Association at Dallas, Texas, May 29–31. His subject was "Regulation without Regimentation." J. W. SELBY, chief scout of the Shell Oil Company, Inc., Houston, Texas, is the new president of the National Oil Scouts and Landmen's Association.

E. G. GAYLORD, Standard Oil Company of California, San Francisco, has been appointed chairman of the 1941 advisory committee on fundamental research on occurrence and recovery of petroleum of the American Petroleum Institute's Division of Production. C. A. YOUNG, American Petroleum Institute, Dallas, is secretary of the committee. Members of the committee are: R. C. ALDEN, Phillips Petroleum Company, Bartlesville, Oklahoma; R. F. BAKER, The Texas Company, New York; F. R. CLARK, The Ohio Oil Company, Tulsa; J. B. CLARK, Stanolind Oil and Gas Company, Tulsa; B. B. COX, Socony-Vacuum Oil Company, Inc., New York; M. L. HAIDER, Standard Oil Development Company, New York; K. C. HEALD, Gulf Refining Company, Pittsburgh; F. H. LAHEE, Sun Oil Company, Dallas; C. V. MILLIKAN, Amerada Petroleum Corporation, Tulsa; T. V. MOORE, Humble Oil and Refining Company, Houston; R. B. ROARK, Shell Oil Company, Inc., Tulsa; O. L. ROBERTS, The Atlantic Refining Company, Philadelphia; A. C. RUBEL, Union Oil Company of California, Los Angeles; and the following alternates: A. G. LOOMIS, Shell Development Company, Emeryville, California; H. C. PYLE, Union Oil Company of California, Los Angeles; and H. D. WILDE, JR., Humble Oil and Refining Company, Baytown, Texas.

The Tulsa Geological Society has elected new officers as follows: president, JOHN L. FERGUSON, Amerada Petroleum Corporation; first vice-president, LOUIS H. LUKERT, The Texas Company; second vice-president, HOWARD J. CONHAIM, consulting geologist; secretary-treasurer, M. R. SPAHR, Carter Oil Company; editor, CHARLES RYNIKER, Gulf Oil Corporation. The new officers and the retiring president, JOSEPH L. BORDEN, of The Pure Oil Company, together with the following form the council of the society: LOUIS ROARK, Margay Oil Corporation; JOHN W. MERRITT, Geochemical Service Corporation; and WILLIAM E. HORKEY, Superior Oil Corporation.

JOHN L. LESTER, recently with the Shell Oil Company, Inc., at Centralia, Illinois, is a First Lieutenant in the 350th Field Artillery, at Camp Livingston, Louisiana.

EDGAR R. BREED, JR., recently with the Shell Oil Company, Inc., at Centralia, Illinois, is an Ensign in the Naval Reserves. He may be addressed in care of the postmaster, New York City.

CLAUDE M. LANGTON has left the Lane-Wells Company to work for the Houston Oil Company, Houston, Texas.

NATHAN C. DAVIES, consulting geologist, has moved from Fairfield, Illinois, to 2232 East Powell, Evansville, Indiana.

C. F. BUCHNER has resigned as vice-president and general manager of W. C. McBride, Inc., because of illness. NOEL H. STEARN is vice-president.

At Northwestern University the department of geology and geography recently has been addressed by the following guest speakers: NEVIN M. FENNEMAN of the University of Cincinnati ("Desert Forms and Desert Processes"); HARRISON SCHMITT, consulting geologist ("The Training of the Mining Geologist"); H. E. MCKINSTRY of the University of Wisconsin ("Structural Control in Certain Australian Gold Districts"); E. S. BASTIN of the University of Chicago ("Silver Ores as Illustrations of Problems of the Mining Geologist"); THERON WASSON, chief geologist, Pure Oil Company ("Petroleum Prospecting Methods in Latin America"); SHERWIN F. KELLY, consulting geophysicist ("Magnetic and Electrical Technique in the Mining and Petroleum Fields"); and H. K. GLOYD, director, Chicago Academy of Sciences ("Desert Ecology").

DENYS H. BACK, formerly with the Yuan Development Company, 1422 Esperson Building, Houston, has resigned to rejoin the Royal Air Force and is leaving for London, England, immediately.

The South Louisiana Geological Society held its regular monthly meeting on May 20, in Lake Charles. ED. W. OWEN, president of the Association, gave a short talk on the future policies and plans of the Association. H. R. KAMB, Arkansas Fuel Oil Company, Shreveport, Louisiana, gave a paper on "Olla Field, LaSalle Parish, Louisiana."

A. I. LEVORSEN, geologist, Tulsa, Oklahoma, spoke on "Geology and Oil Discovery," at the 9th annual petroleum conference of the Illinois-Indiana Petroleum Association at Robinson, Illinois, June 7.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 25, NO. 6 (JUNE, 1941), P. 1200

FIELD TRIP

KANSAS GEOLOGICAL SOCIETY
FIFTEENTH ANNUAL FIELD CONFERENCE, AUGUST 27–31

The Kansas Geological Society announces its fifteenth annual field conference to be held in central and eastern Missouri and western Illinois, August 27 to 31, inclusive. This conference is to be held in coöperation with the University of Missouri, the Missouri Geological Survey and Water Resources, and the State Geological Survey of Illinois.

The conference will study the pre-Pennsylvanian rocks of central and eastern Missouri and the Mississippian rocks in Illinois. Principal attention will be given to the Siluro-Devonian and the Ordovician rocks in Missouri. The conference leaders will be E. B. BRANSON, head of the department of geology at the University of Missouri; H. A. BUEHLER, State geologist of Missouri; and M. M. LEIGHTON, chief of the Geological Survey of Illinois. They will be assisted by H. S. MCQUEEN, assistant State geologist of Missouri, and J. MARVIN WELLER, head of the stratigraphy and paleontology division of the Illinois Geological Survey. The conference will convene at Sedalia, Missouri, and proceed as follows.

First day, Wednesday, August 27.—East and north from Sedalia by way of Boonville, Arrow Rock, Glasgow, and Fayette to Columbia, Missouri. Section extends from Jefferson City (Arbuckle) through Ordovician, Devonian, and Mississippian to lower Pennsylvanian rocks.

Second day, Thursday, August 28.—South from Columbia along Missouri River, crossing to Jefferson City and returning to Columbia at night. Examine in one outcrop along bluffs of Missouri River a section extending from Mississippian to Ordovician in which there are five unconformities.

Third day, Friday, August 29.—East of Columbia to view westernmost exposure of Plattin. Several new quarries have excellent exposures of Mississippian and Ordovician. Reach St. Louis in evening, probably at a hotel in west end of city near Forest Park.

Fourth day, Saturday, August 30.—North from St. Louis, crossing Cap-au-Gres fault and associated folds. Section from Canadian up to Ste. Genevieve. Stratigraphy of Ordovician, Silurian, and Kinderhook-Mississippian. Stop at Hannibal, Missouri, in evening.

Fifth day, Sunday, August 31.—Cross Mississippi River. Excellent exposures of Kinderhook and other Mississippian formations. Trip ends at Keokuk, Iowa.

Several papers on the stratigraphy and structure including maps and sections of the area will be included in the guide book.

Private automobiles will be used for transportation. If you are unable to bring your own car, the committee will undertake to provide you a seat in the car of another participant.

The registration fee will not exceed $9.00 and includes the price of one copy of the guide book. Additional copies may be purchased for not more than $5.00. All participants must pay the registration fee, no matter how much of the conference they attend.

It is important that the committee be able to make an estimate of the number of participants at the earliest possible date. If you hope to attend, or wish to receive further notices of the conference, write the Kansas Geological Society, 412 Union National Bank Building, Wichita, Kansas.

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927 Humboldt Street

Dinner meetings, first and third Mondays of each month, 6:15 P.M., Auditorium Hotel.

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KANSAS GEOLOGICAL SOCIETY

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Secretary-Treasurer - - - - - - Lee H. Cornell
Stanolind Oil and Gas Company
Manager of Well Log Bureau - Harvel E. White

Regular Meetings: 7:30 P.M., Geological Room, University of Wichita, first Tuesday of each month. Visitors cordially welcomed.

The Society sponsors the Kansas Well Log Bureau which is located at 412 Union National Bank Building.

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Michigan State College, East Lansing
Business Manager - - - - - - - Lee C. Miller
State Proration Officer, Lansing

Meetings: Monthly dinner meetings rotating between Saginaw, Mt. Pleasant, and Lansing. Informal dress.

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Meetings will be announced.

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Historian - - - - - - - - - Robert B. Totten
Phillips Petroleum Company

Meets the first Friday of every month, 7:30 P.M., Civil Courts Room, Caddo Parish Court House. Special dinner meetings by announcement.

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Secretary - - - - - - - - - - E. M. Baysinger
Box 210
Treasurer - - - - - - - - - - Baker Hoskins
Shell Oil Company, Inc., Box 598

Meetings: Luncheon 1st Wednesday at Noon (12:00) and business meeting third Tuesday of each month at 7.00 P.M. at the Majestic Hotel. Visiting geologists are welcome.

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MISSISSIPPI GEOLOGICAL SOCIETY

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Consulting Geologist, 1205 Tower Building

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Gulf Refining Company, Box 1105

Secretary-Treasurer - - - - David C. Harrell
Carter Oil Company, Box 1490

Meetings: First and third Wednesdays of each month ,from October to May, inclusive, at 7:30 P.M., Edwards Hotel, Jackson, Mississippi. Visiting geologists welcome to all meetings.

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OKLAHOMA CITY, OKLAHOMA

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Consulting Geologist, 1801 Petroleum Bldg.

Secretary-Treasurer - - Graydon H. Laughbaum
Sinclair Prairie Oil Co., 703 Colcord Bldg.

Meetings, Ninth Floor, Commerce Exchange Building: Technical Program, second Monday, each month, 8:00 P.M.; Luncheons, every Monday, 12:15 P.M.

THE STRATIGRAPHIC SOCIETY OF TULSA

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The Texas Company

Secretary-Treasurer - - - - - Floyd L. Swabb
Sun Oil Company, Box 1348

Meetings: Second and fourth Wednesdays, each month, from October to May, inclusive, at 8:00 P.M.

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Vice-President - - - - - - - Tom L. Coleman
U. S. Geological Survey, Box 719

Secretary-Treasurer - - - - - - Bob Hancock
Magnolia Petroleum Company, Box 299

Dinner meetings will be held at 7:00 P.M. on the first Wednesday of every month from October to May, inclusive, at the Ardmore Hotel.

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Amerada Petroleum Corporation

Secretary-Treasurer - - - - - Martyna Garrison
Amerada Petroleum Corporation

Meets the fourth Monday of each month at 8:00 P.M., at the Aldridge Hotel. Visiting geologists welcome.

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Editor - - - - - - - - - - Charles Ryniker
Gulf Oil Corporation

Meetings: First and third Mondays, each month, from October to May, inclusive, at 8:00 P.M., University of Tulsa, Kendall Hall Auditorium. Luncheons: Every Thursday (October-May), Michaelis Cafeteria, 507 South Boulder Avenue.

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Meetings: Regular luncheons, first Monday of each month, 12:15 noon, Petroleum Club, Adolphus Hotel. Special night meetings by announcement.

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Shell Oil Company, Inc., Box 2037

Meetings: Monthly and by call.
Luncheons: Every Monday at 12:00 noon, Blackstone Hotel.

TEXAS

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Ambassador Oil Corporation

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Meetings: Luncheon at noon, Worth Hotel, every Monday. Special meetings called by executive committee. Visiting geologists are welcome to all meetings.

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Regular meeting held every Thursday at noon (12 o'clock) above Kelly's Restaurant, 910 Texas Avenue. For any particulars pertaining to the meetings write of call the secretary.

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Tide Water Associated Oil Company
924 Hamilton Building

Luncheons and evening programs will be announced.

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Magnolia Petroleum Company, 1709 Alamo
National Building, San Antonio

Meetings: Third Friday of each month alternately in San Antonio and Corpus Christi. Luncheon every Monday noon at Milam Cafeteria, San Antonio, and at Plaza Hotel, Corpus Christi.

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Meetings: Every third Friday at 8:00 P.M. at the University of Texas, Geology Building 14.

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Tide Water Associated Oil Company, Box 181

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Stanolind Oil and Gas Company

Meetings will be announced

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Owens, Libbey-Owens Gas Department
Box 1375, Charleston, W.Va.

Meetings: Second Monday, each month, except June, July, and August, at 6:30 P.M., Kanawha Hotel.

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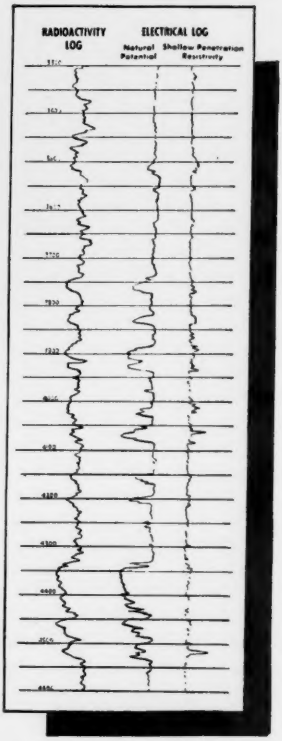

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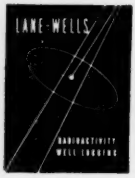
To the owners and operators of wells which were completed without Electrical Open Hole Logging, Lane-Wells Radioactivity Well Logging makes available the most complete information on formation characteristics possible to obtain. Errors which resulted from "hurry up" drilling practices can be detected. Productive sands cased off on the way down can be accurately located and opened for production.

Operators who have used this new service can tell you that Radioactivity Well Logging is an important Lane-Wells Technical Oil Field Service designed to get more oil at lower production costs.



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The complete story of Radioactivity Well Logging is available. Write Lane-Wells, Los Angeles.

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